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Boston, Water

FIRST ANNUAL REPORT

OF THE

Boston METROPOLITAN WATER AND SEWERAGE BOARD.

COMPLIMENTS OF . . .

METROPOLITAN WATER AND SEWERAGE BOARD.

HENRY H. SPRAGUE, CHAIRMAN.
HENRY P. WALCOTT.
JAMES A. BAILEY, JR.

1 ASHBURTON PLACE,
BOSTON.

WILLIAM N. DAVENPORT, Secretary.

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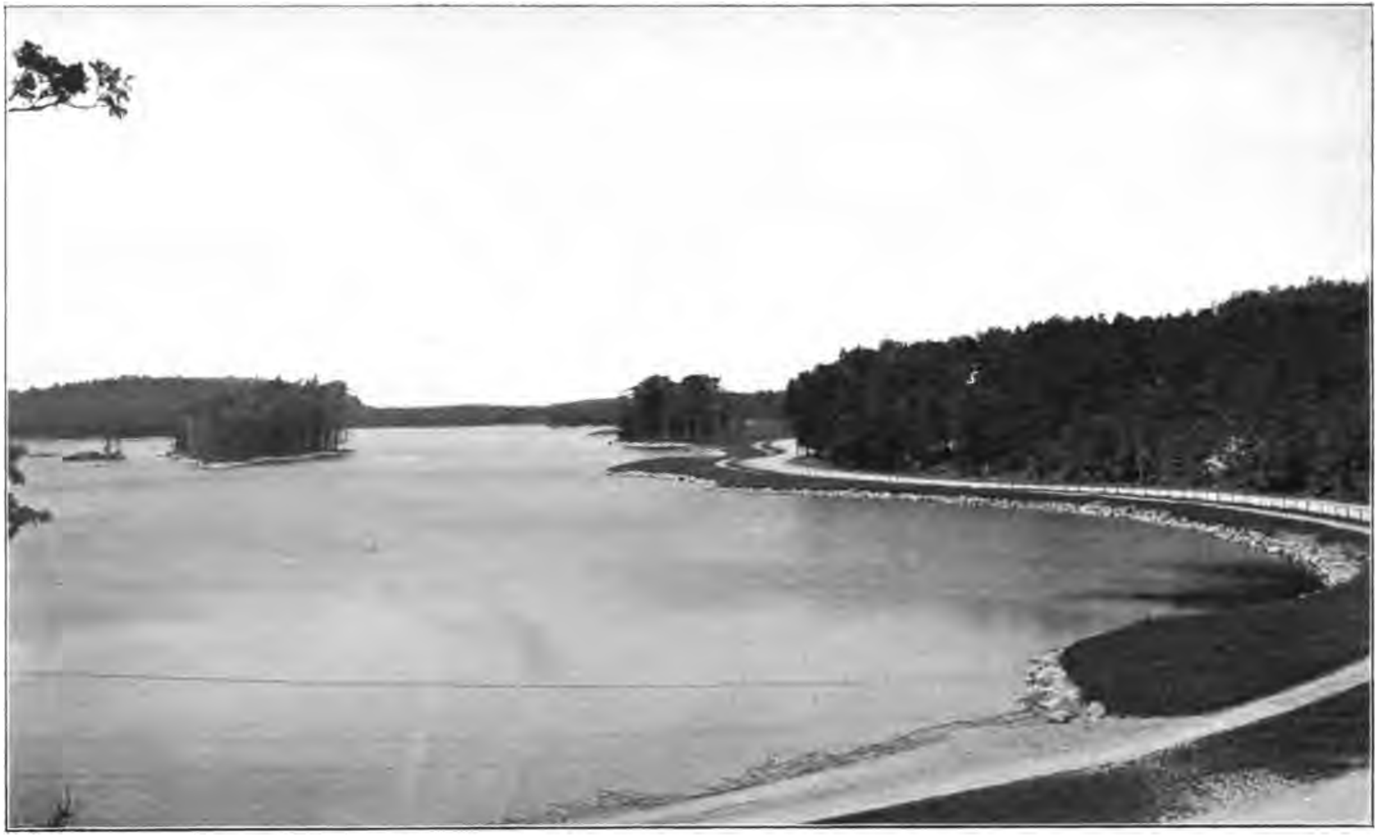


SPOT POND—VIEW OF NORTHWESTERLY PART AFTER IMPROVEMENT.

METROPOLITAN WATER AND SEWERAGE BOARD.

To the Honorable the Senate and House of Representatives of the Commonwealth of Massachusetts in General Court assembled.

The Metropolitan Water and Sewerage Board, established under the provisions of chapter 168 of the Acts of the year 1901, respectfully submits its

FIRST ANNUAL REPORT.

The Metropolitan Water Board and the Board of Metropolitan Sewerage Commissioners were consolidated by the said Act of the year 1901, which was approved and took effect on March 20. The present report is made to embrace the work and operations of the Metropolitan Water Board for the period beginning with January 1, 1901, the date of its last annual report, to March 20, 1901; and of the Board of Metropolitan Sewerage Commissioners for the period beginning with October 1, 1900, the date of its last annual report, to March 20, 1901; and of the Metropolitan Water and Sewerage Board from its organization to and including December 31, 1901. The previous report of the Water Board was the sixth annual report, and of the Sewerage Commissioners the twelfth annual report.

I. ORGANIZATION AND ADMINISTRATION.

(1) BOARD, OFFICERS AND EMPLOYÉS.

Prior to the consolidation of the two Boards, the Metropolitan Water Board consisted of Henry H. Sprague, chairman, Wilmot R. Evans and Henry P. Walcott, M.D.; and the Board of Metropolitan Sewerage Commissioners consisted of James A. Bailey, Jr., chairman, Tilly Haynes and George A. Kimball.

The consolidated Board was constituted by the appointment of Henry H. Sprague, chairman, Henry P. Walcott, M.D., and James A. Bailey, Jr. William N. Davenport was appointed secretary and executive officer of the Board, and Alfred F. Bridgman, auditor and purchasing agent. Prior to the organization of the new Board, Mr. Davenport and Mr. Bridgman had served in the same capacities in the Water Board. Herbert E. Brayton held the position of clerk and auditor of the Sewerage Commission prior to the consolidation.

The administrative office force has comprised a book-keeper, two assistant book-keepers, an assistant in auditing, a paymaster, a supply clerk, two general clerks, four stenographers, a telephone operator, two messengers, a janitor and a fireman.

Alfred C. Vinton, conveyancer, and George D. Bigelow, assistant conveyancer, of the Water Board, have continued in charge of the work of conveyancing of the consolidated Board. They have been assisted by Miss Alline E. Marcy, title examiner, and by one stenographer, and, for a portion of the time, by two stenographers. It has been necessary to employ Miss Celia M. Tibbetts a part of the time for service at the Worcester Registry of Deeds.

Frederic P. Stearns, the chief engineer of the Water Board, was appointed chief engineer of the consolidated Board, with special charge of the Water Works.

Joseph P. Davis, Alphonse Fteley and Hiram F. Mills have been continued as consulting engineers.

For the Water Works the following have also been continued in charge of the various departments: Dexter Brackett, engineer of Distribution Department; Desmond FitzGerald, engineer of Sudbury Department; Thomas F. Richardson, engineer of Dam and Aqueduct Department; Hiram A. Miller, engineer of Reservoir Department; Horace Ropes, engineer of Weston Aqueduct Department; and Alfred D. Flinn, principal office assistant.

The engineering force employed on the Water Works, in construction and maintenance, has, upon the average during the year, comprised, in addition, 9 division engineers, 33 assistant engineers and others in various engineering capacities and as sanitary inspector, clerks, stenographers and messengers, to the number of 120, — in all, 162. The maximum engineering force employed at any one time during the year on construction and maintenance was 190.

There have also been employed inspectors, other than engineering inspectors, to the maximum number of 12. Day-labor forces under the general supervision of the engineers and the immediate direction of foremen, varying in numbers from time to time, have been employed in pipe laying, in general improvements and repairs and in the performance of minor operations.

In addition, a regular maintenance force has been required at the pumping stations and upon the reservoirs, aqueducts, pipe lines and other works, numbering upon the average during the year 185. This force at the end of the year numbered 170, and was distributed among the various departments as follows: Distribution Department, 100; Dam and Aqueduct Department, 16; Sudbury Department, 54.

The maximum number of men employed upon contracts by the various contractors upon the Water Works during the year was for the week ending August 24, when the number amounted to 2,668.

William M. Brown, the chief engineer of the Sewerage Commission, was continued by the new Board as engineer of the Sewerage Works.

He has been assisted by 5 division engineers who have been in charge of the various sections of sewer construction, 12 assistant engineers, and 78 others who are employed in various engineering capacities, and as clerk, stenographer and messenger in the department. The maximum engineering force employed at any one time during the year on construction and maintenance of the works was 108.

There have also been employed inspectors, other than engineering inspectors, to the maximum number of 26. Day-labor forces under the general supervision of the engineers and the immediate direction of foremen have been employed in making connections between existing Metropolitan sewers and the sections of the sewerage works recently completed in Chelsea, Malden and Melrose, in construction of parts of Section 60 in Melrose, which had been abandoned by the contractor, and, in Section 67, the pipe crossing of Stony Brook in Hyde Park.

The maintenance force required for the Sewerage Works, exclusive of engineers before enumerated, has upon the average numbered 79. This force at the end of the year numbered 83, and was distributed between the two departments as follows: South Metropolitan System, 6; North Metropolitan System, 77.

The maximum number of men employed upon contracts by the various contractors upon the Sewerage Works during the year was for the week ending September 7, 1901, when the number amounted to 1,516.

(2) OFFICES AND BUILDINGS.

The office of the Metropolitan Water and Sewerage Board was established in the buildings numbered 1 and 3 Ashburton Place, at the corner of Somerset Street, which had been occupied at the beginning of the year under a lease made by the Water Board. In these buildings are located, also, the offices of the secretary, the auditor and the conveyancers, and the main engineering office of the Metropolitan Water Works. The engineering department of the Sewerage Works has continued to occupy a portion of the rooms in the Pemberton Building where the Sewerage Commissioners had been located since January 1, 1901.

The headquarters of the Wachusett Reservoir and Wachusett Dam and Aqueduct departments of the Water Works have been maintained in the office building in Clinton. Branch offices of the Wachusett Reservoir Department have been maintained at the North Dike in Clinton, at Sawyer's Mills in Boylston and in West Boylston, and a fourth was established in May in the easterly part of West Boylston. For the work of the Wachusett Dam and Aqueduct Department a branch office has been maintained at the dam. The main office of the Weston Aqueduct Department has remained in Saxonville, and branch offices have been located in Framingham Centre, Wayland and Weston. Headquarters of the Distribution and Sudbury departments have been maintained in Boston. For the Sudbury Department a branch office has been maintained at South Framingham. The headquarters for the maintenance department of the Water Works in the northern part of the District have been in buildings recently erected in the Glenwood Pipe Yard in Medford, where there are offices, shops, store rooms and stables. The maintenance force for the southern portion of the District is located in buildings at the Chestnut Hill Reservoir.

There are also maintained, in connection with the Water Works, the Chestnut Hill high-service and low-service pumping stations; the Spot Pond, Arlington and West Roxbury pumping stations; the Clinton sewerage pumping station at Clinton; the Mystic pumping station at Medford, not now operated; as well as the gate-houses at the several reservoirs, dwellings for attendants, and various other buildings for operating purposes.

There have been maintained, in connection with the construction of the Sewerage Works, branch engineering offices at Forest Hills, East Milton, Hyde Park, Hough's Neck and Melrose. In addition to the above, twenty-two portable booths have been in use along the line of the work. For the operation of the works there have been maintained the Deer Island, Charlestown, East Boston, Alewife Brook and Quincy pumping stations.

(3) CONVEYANCING.

The conveyancers of the Water Board had charge of the examination of titles and the preparation of deeds, instruments and other papers required in the acquisition of real estate, a work which, previous to the consolidation of the two Boards, was performed for the Sewerage Commission by attorneys appointed by the Attorney-General. Since the consolidation the former conveyancers have performed the entire work.

Considerable increase in the work of conveyancing has been made by the addition of the titles connected with the real estate acquired for the high-level sewer and the lands which are embraced in the line of the Weston Aqueduct.

Titles have been completed and the necessary papers drafted in 133 cases of settlement. Of these settlements, 106 were on account of the Water Works and 27 on account of the Sewerage Works. In the larger part of the Worcester County cases the preliminary examination of titles had been made, and it was necessary only to revise the titles to date, and to draft and obtain the necessary deeds and other instruments attending the settlement. The lands acquired along the line of the Weston Aqueduct were mostly in the county of Middlesex, and new examination of titles had to be made; and the same was the case with the sewerage titles, which were principally in the counties of Suffolk and Norfolk.

The conveyancers have also been called upon to prepare 20 instruments of taking, — 15 for the Water Works and 5 for the Sewerage Works, by which were acquired 146 estates.

One road location and two discontinuances of 4 roads and parts of 8 other roads were drafted for the Water Works.

There were pending on January 1, 1902, 43 cases in process of settlement. In about one-half of these the papers had been prepared and sent out for execution, but for various reasons there was some delay in returning them; in other cases delay was occasioned by the absence of parties, probate proceedings and the defects of titles; and an unusual number of settlements was effected in the month of December. The total number of settlements on account of the Water Works was 133, as against 116 made in the preceding year. For the Sewerage Works 7 settlements were effected before the consolidation, and 31 have been effected since the consolidation of the two Boards.

A detailed statement of the various takings and settlements is given hereafter.

The conveyancers have been called upon to do a considerable amount of work for the Attorney-General in cases for which petitions or suits for damages have been brought.

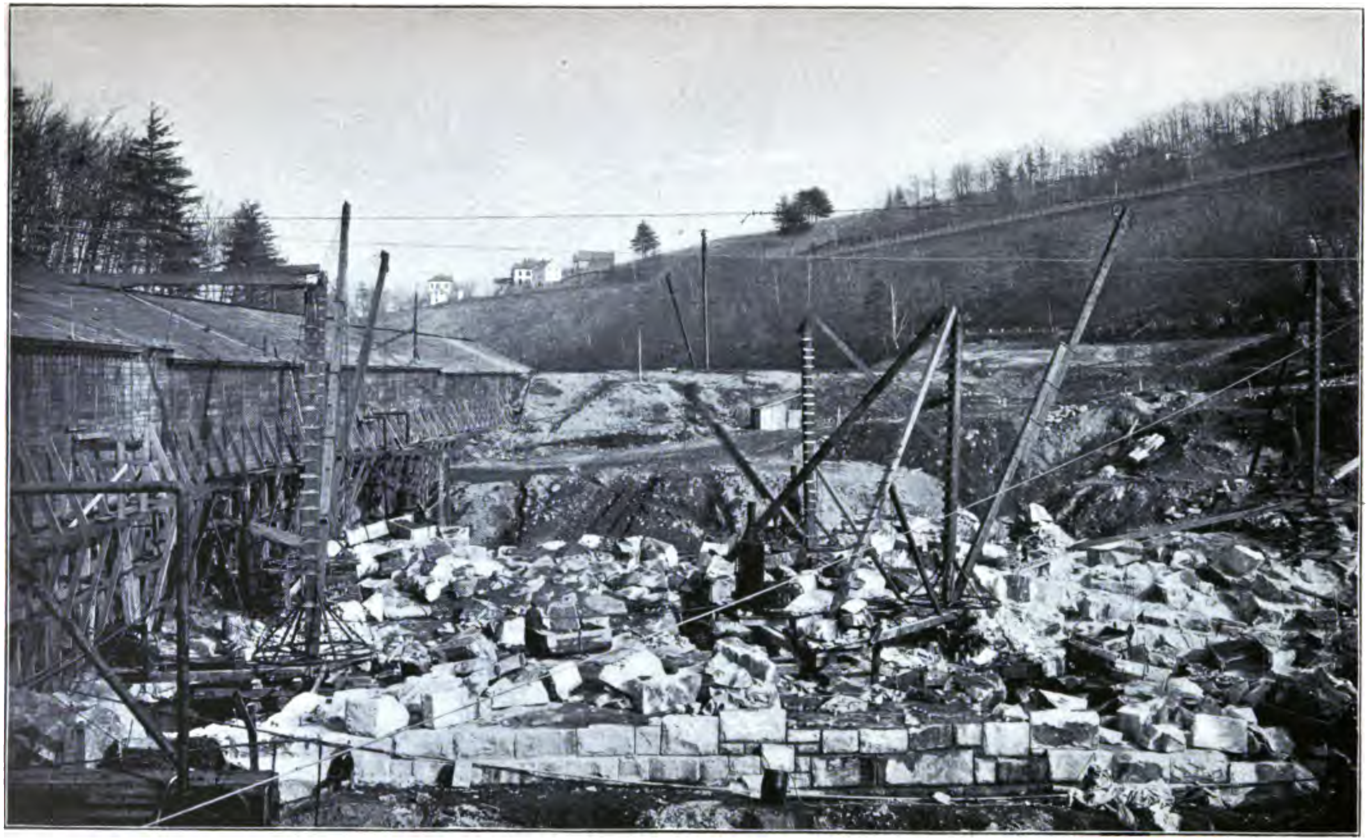
II. WATER WORKS — CONSTRUCTION.

(1) WACHUSETT DAM AND RESERVOIR.

(a) *Wachusett Dam.*

Prior to the beginning of the year, but little actual work had been accomplished under the contract for the building of the Wachusett Dam, which was executed on October 1, 1900. Considerable progress had then been made in the erection of the air-compressor plant, in the building of cableways, and in the installation of other portions of the plant for carrying on the necessary work of excavation. The compressor plant was completed early in the year, and the work of excavation was vigorously carried on. In the meantime, great progress had been made in opening up the quarry and the taking out of stone to be used in the construction of the dam. Excavation for the bed of the structure had been so nearly completed that a beginning of masonry work was made by the laying of the first stone on June 5; and, though considerable other excavation was made after that date, the laying of the stones which are to constitute the dam has been continuously carried on, so that at the end of the year, in addition to the installation of a complete plant for the work, masonry to an extent of more than 28,000 cubic yards has been laid, and for a considerable extent of surface this had reached a height of more than 40 feet above the rock bed.

The progress justifies the expectation that, in accordance with the contract, the dam will be constructed to such a height that, by the spring of 1903, considerable water can be stored behind it. November 15, 1904, is the date fixed for the entire completion of the contract.



WACHUSETT DAM — SHOWING PROGRESS OF MASONRY CONSTRUCTION ON DECEMBER 31, 1901

The contract price for the erection of the dam, according to the quantities estimated, was $1,603,635.00. Work has already been accomplished to an amount of $190,218.24.

(*b*) *Wachusett Reservoir.*

The work of removing the soil from the bottom of the Wachusett Reservoir has rapidly progressed during the year. Of the total amount of soil to be removed, estimated at 6,900,000 cubic yards from 4,200 acres, 3,588,648 cubic yards, or 52 per cent. of the whole, had been removed on December 31, 1901, and 2,116 acres had been stripped. During the year 1901, 1,309,925 cubic yards were removed and 1,358 acres were stripped. The removal of more than one-half of the remainder of the soil is provided for under existing contracts. Nearly all of the soil so removed has been used in the construction of the North Dike, the small amounts of 167,389 cubic yards having been taken for road embankments and 2,420 cubic yards for shallow-flowage areas. The soil is loaded into cars, either directly or after carriage in dump carts, and hauled by locomotives or up inclines to the dike.

The larger part of the area which has been stripped during the year is in the town of Boylston, but the stripping has proceeded so far as to take in a small portion of the easterly part of the town of West Boylston. Small areas in the town of Clinton have also been stripped during the year.

At the North Dike the secondary cut-off trench has been completed, and the main cut-off trench, which had been excavated and partially filled, has been substantially completed. About two-thirds of the entire amount of soil filling required for the construction of the North Dike has been deposited, and a considerable portion of the embankment has been completed on the water side of the dike, ready for the slope paving.

During the year, in West Boylston, 2 mills, 1 hotel, 1 hall, 53 dwellings and 14 barns have been torn down, removed or destroyed, making a total of 150 buildings which have so far been disposed of. Considerable work has been required for the repairing of buildings which are retained, and which are, in general, rented to people employed upon the work.

(*c*) *Location, Construction and Discontinuance of Roads.*

The location of a new road to be built across the reservoir in West Boylston, connecting Sterling and Lancaster streets, on the northerly side of the reservoir, with Worcester Street, on the southerly side, has been determined, and the location has been agreed to by the County Commissioners.

During the year discontinuances have been made of 12 public ways, or parts of ways, in the towns of Boylston and West Boylston.

It has been necessary to keep several of the roads, discontinued in this or preceding years, in condition for travel, for the purposes of the Board and of contractors, and considerable repairs have been required. Much work has also been done in the making of surveys for the relocation of roads at the upper end of the reservoir, which are to take the place of those hereafter to be discontinued.

The following is a list of roads, with dates of discontinuance, which have been discontinued in the year 1901, on account of the work of construction in the Wachusett Reservoir: —

LOCATION.	Description.	Date of Discontinuance.
Boylston, . . .	That part of the River Road between the southerly end of the part discontinued December 30, 1899, and the new highway from Boylston to Clinton.	June 1, 1901.
Boylston, . . .	That part of the old road from Sawyer's Mills to West Berlin leading easterly from the southerly end of that part of the River Road discontinued December 30, 1899, to the new highway from Boylston to Clinton.	June 1, 1901.
Boylston, . . .	Road leading southerly from the old road from Sawyer's Mills to West Berlin to the road from Sawyer's Mills to Berlin.	June 1, 1901.
Boylston, . . .	That part of the road from Sawyer's Mills to Berlin between the River Road and the new highway from Boylston to Clinton.	June 1, 1901.
West Boylston and Boylston.	That part of East Main Street and its continuation in Boylston and the Scar Bridge Road between Beaman Street and land of Lyman P. Kendall.	June 1, 1901.
Boylston and West Boylston.	Part of the road from Sterling to Boylston Centre leading southerly from Bruce Street to Scar Bridge Road.	June 1, 1901.
Boylston, . . .	That part of the road from West Boylston to Clinton between the continuation of East Main Street in Boylston and the road to Sterling.	June 1, 1901.
Boylston and West Boylston.	That part of the Dover Road between the easterly line of the new Shrewsbury Road and land of Lyman P. Kendall.	June 1, 1901.
West Boylston, . .	The short curved road between Temple Street and the Dover Road.	June 1, 1901.
Boylston, . . .	Road running northeasterly from the Dover Road to Scar Bridge.	June 1, 1901.
West Boylston and Boylston.	Temple Street in West Boylston and the continuation thereof called the Sand Hill Road in Boylston to land of John N. Flagg.	June 1, 1901.
Boylston, . . .	A short curved road leading easterly from the new Shrewsbury Road to the Sand Hill Road.	June 1, 1901.

(*d*) *Relocation of the Central Massachusetts Railroad.*

As the result of conferences which have been had during the year with the authorities of the Boston & Maine Railroad, formerly the lessee, now the owner, of the Central Massachusetts Railroad, additional surveys have been made for the purpose of determining upon the relocation of the railroad around the basin. No definite arrangement has been reached, but it is expected that an agreement between the Board and the railroad company will early in the year be effected, and that the construction of the new portion of the railroad will be begun. Great speed will be required in order to complete the work by the time when it will become necessary to abandon the old road-bed for the beginning of the filling of the reservoir.

(*e*) *Clinton Catholic Cemetery.*

The work of the removal of the bodies from the St. John's Catholic Cemetery in Clinton, which was included within the limits of the proposed reservoir, to the new cemetery in the town of Lancaster, had been substantially completed in the year 1900. In the progress of the more extensive excavations which were made a few additional bodies were found, and were removed by the representatives of the Cemetery Association. The total number of bodies removed was 3,872.

There is a balance due, under the tripartite agreement made between the Board, the Roman Catholic Bishop of Springfield and the St. John's Catholic Cemetery Association. The Board has been ready for the final settlement and to pay the balance due under the agreement, and to convey the lands held by it and included within the new cemetery lot to the St. John's Catholic Cemetery Association, as called for, on the receipt of a deed of the old cemetery lot, and a release of all claims and damages as provided.

(*f*) *Sanitary Inspection of Watershed.*

The watershed of the South Branch of the Nashua River above Clinton has been divided into districts, according to the natural drainage line of the brooks, and a careful inspection has been made of each of these districts as to the sources of pollution, and many cases of pollution arising from defective house drainage and other causes have been remedied. A constant examination and inspection of the camps of the laborers and of other buildings within the basin

(3) Chestnut Hill and Spot Pond Pumping Stations.

The low-service pumping station at Chestnut Hill and the high-service pumping station at Spot Pond were both finally completed early in the year, and the grounds about them were put in order. The three new engines at the Chestnut Hill station and the one new engine at Spot Pond, which had been previously put in operation, received their final finishing and were accepted after the making of the official tests required.

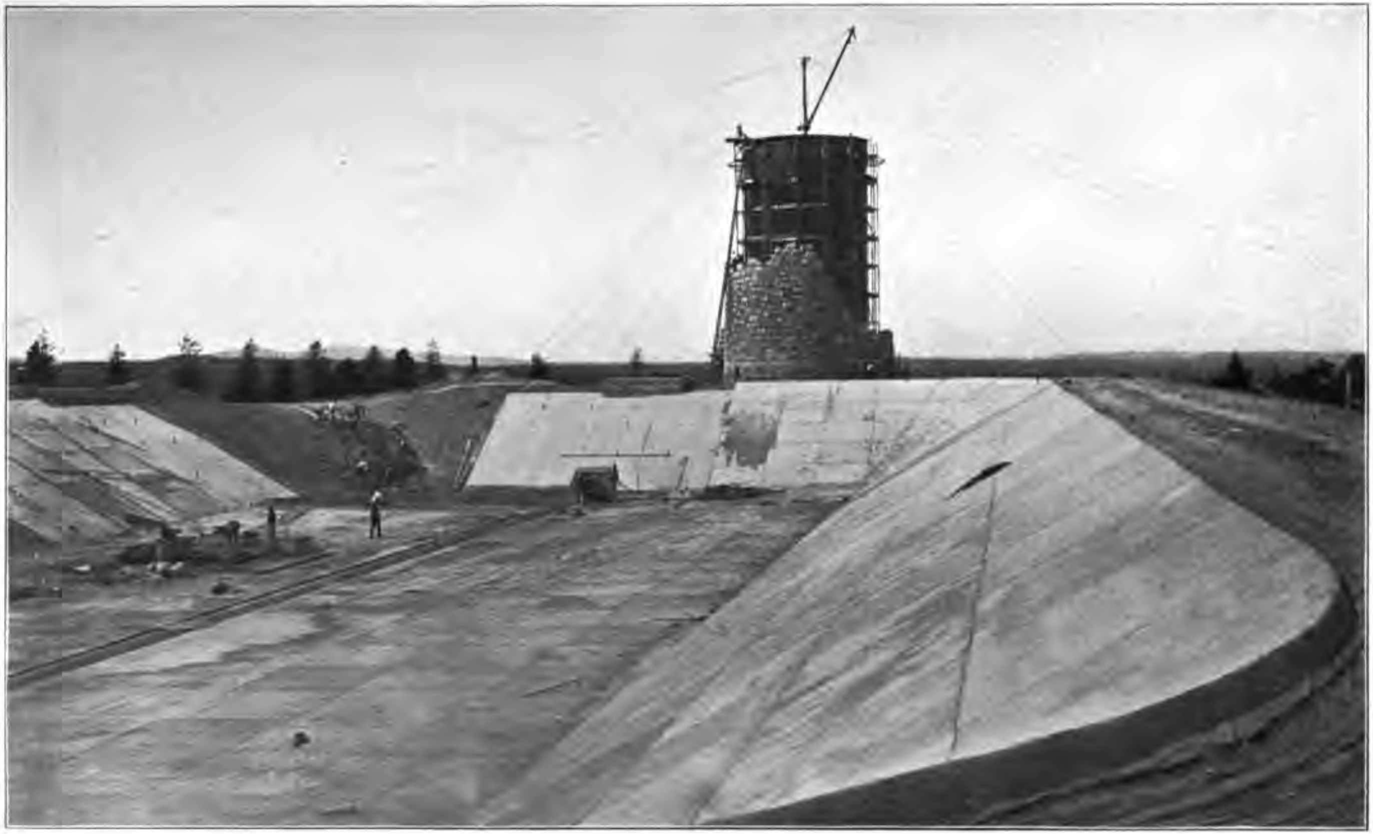
The expenditures on account of the Chestnut Hill low-service pumping station, exclusive of those for engineering, have been, for building and appurtenances, $223,613.22; for engines, boilers and their connections, $195,399.03, — a total of $419,012.25.

The expenditures on account of the Spot Pond pumping station have in like manner been for building and appurtenances, $129,811.79; for engines, boilers and their connections, $137,846.45, — a total of $267,658.24.

(4) Forbes Hill Reservoir and Standpipe at Quincy.

The reservoir at Forbes Hill in Quincy, which was in process of construction at the date of the last report, has been finished and put into service. The granolithic walks around it have been laid, and the surfacing and seeding of the embankments have been accomplished. This reservoir is in the form of a rectangle, about 340 feet long and 160 feet wide at the high-water line, with sloping sides, both bottom and sides being covered with concrete. The area of water surface is 1.23 acres, the depth of the water when full is 17 feet, and it has a capacity exceeding 5,000,000 gallons.

The steel standpipe erected in connection with the reservoir was finished in the year 1900, and the construction of a masonry tower encircling the standpipe was begun during the current year, but, owing to delay in obtaining necessary granite, its completion has been delayed, but it will be finished early in the coming year. When completed, the tower will be provided with an observation roof to be reached by a spiral staircase. The tower will be 46 feet in diameter at the base and 75 feet high; and its roof, which will, in accordance with the agreement made with the city of Quincy, be open to visitors, will command a view of the country for many miles around.



FORBES HILL RESERVOIR AND STAND-PIPE — PARTIALLY CONSTRUCTED.

(5) STONEHAM PIPE LINES AND BEAR HILL RESERVOIR.

The agreement made with the town of Stoneham, upon its admission into the District, required the laying of pipe lines in order to make connection with the water system of the town; and also the building of a reservoir on Bear Hill in the Middlesex Fells, in order to furnish water at a greater pressure for the town than would be supplied by the Fells Reservoir. Accordingly, a pipe has been laid from the Spot Pond pumping station around the northeasterly end of Spot Pond to the junction of Main and South streets in Stoneham, and thence one branch laid to the Bear Hill Reservoir and another to Stoneham Square to a connection with the main pipe of the town. The entire length of pipe line laid was 12,216 feet. The line to Stoneham Square was completed and the town of Stoneham supplied with water on October 21.

The building of the reservoir near the summit of Bear Hill was begun and brought nearly to completion during the year. This reservoir is built across a depression in the rocky ridge forming the hill at a height 137 feet above the surface of Spot Pond. All of the earth, beside considerable rock, was excavated from the area enclosed, and the reservoir has a capacity to hold 2,000,000 gallons of water. Connection was made with the pipe line from Spot Pond, and the work was so far advanced at the end of the year that the reservoir was partly filled with water.

(6) WESTON AQUEDUCT AND RESERVOIR.

The surveys and other preliminary work had been begun at the end of the preceding year, and had so far advanced in the early spring of this year that it was possible to determine the final location and design of the aqueduct. The aqueduct extends from the Sudbury Dam in Southborough through portions of Framingham, Wayland and Weston, a distance of 13.44 miles. Of this distance, 9.14 miles will be of covered masonry, built in open trench, 2.30 miles in five different tunnels, 1.02 miles in open channel and reservoir, and the remainder in pipe lines, to connect at the beginning with the Sudbury Reservoir, and steel siphon pipes across the valleys of the Sudbury River and of Happy Hollow in Wayland. The aqueduct will in general be of horse-shoe form, like that of the Wachusett Aqueduct, and will have a capacity of 300,000,000 gallons daily.

Lands and easements for the construction of a large portion of the aqueduct were acquired in May, and contracts were made for the construction of the portions of the aqueduct which would require the longest time for their completion. The work of construction embraces 15 sections, and at the end of the year contracts had been entered into for the construction of about 93 per cent. of the entire length of the aqueduct.

An equalizing reservoir is to be built near the eastern or lower end of the aqueduct in the town of Weston. A site suitable for the purpose was found in the valley about a mile from the terminal chamber which is in the easterly part of Weston near the Charles River. The reservoir, including a short open channel connected with it, has an area of 66.6 acres, and will have a total available capacity exceeding 200,000,000 gallons. The soil and organic matter are to be removed from the deeper portions of the reservoir area, and other material is to be excavated and deposited upon the adjacent land, so that in no case shall there be a less depth than 11 feet.

The work requires the building of 39 culverts for streams, beside others which will be required for the crossing of roads and private ways, 15 crossings of public highways and 49 private crossings. The work also requires the building of several structures for siphon chambers, screen chambers, gate-houses and terminal chamber.

Pipes will be laid to convey the water from the termination of the aqueduct in Weston by gravity to Spot Pond and to other parts of the Metropolitan District.

At the end of the year about 23 per cent. of the total length of aqueduct to be built in open trench had been accomplished. Owing to the greater length of time necessary for the installation of the plant required for the construction of the tunnels, less progress in tunnel work has so far been made, a little less than 1,200 feet of excavation having been accomplished.

All the contracts for aqueduct and reservoir and other structures will provide that the work shall be completed on or before August 1, 1903.

(7) PIPE LAYING.

The laying of a 24-inch pipe line in the channel of the Mystic River, between Charlestown and Chelsea, was completed on March 15, 1901. There was constructed, in which to place the pipes, a submarine tunnel of masonry, 6 feet in internal diameter, and having two shafts, 62 feet in depth.

Considerable changes in the pipe line in Adams Street in Quincy were necessitated by the construction of the Metropolitan sewer in the street; and, likewise, the pipe line in Bennington Street in East Boston was relaid on account of a change in the grade of the street.

The length of pipe lines now in operation is 72 miles.

(8) POLICE PROTECTION.

Police protection has been afforded, in accordance with the requirements of the Metropolitan Water Act, in places where active construction has been carried on. The police officers have been appointed by the various towns in which their services have been required, and they have been subject to the town authorities in the performance of their duties, but they have been paid for their services by the Board.

For the Wachusett Reservoir District there have been employed 13 officers in the town of Clinton, 5 officers in the town of Boylston, 1 of whom is mounted, 1 in the town of West Boylston and 1 mounted officer in the town of Sterling. The officers in all these towns except West Boylston have been appointed special policemen for the other towns.

On account of the construction of the Weston Aqueduct in the towns of Framingham, Wayland and Weston, 6 police officers have been appointed in the town of Framingham, 3 in Wayland, and 2 in Weston, with an additional officer for service on Sundays.

(9) PURCHASES AND TAKINGS OF LAND.

The Board has continued the takings of lands required for the construction of the Wachusett Reservoir as fast as the necessary surveys have been completed and determination has been reached as to the limits required. The takings already made embrace all but about 410 acres of the entire area which is to be acquired for the reservoir, and a large proportion of the 410 acres has been purchased.

Considerable takings have also been made for the Weston Aqueduct and for the improvement of the Sudbury watershed, and smaller takings have been made for the Clinton sewerage and for distribution purposes.

The takings of real estate for the Metropolitan Water Works during the year have numbered 15, affecting an area of 617.715 acres; 576.145 acres were taken in fee, and easements and other rights were taken in 41.570 acres.

List of Takings for Metropolitan Water Works from January 1, 1901, to December 31, 1901.

No.	LOCATION AND DESCRIPTION.	Former Owners.	Recorded.	Purpose of Taking.
			1901.	
70	Newton (on Manet Road and Ward Street). Area, 5.09 acres in fee.	City of Newton.	Mar. 5.	Waban Hill Reservoir.
71	Clinton and Lancaster (High Street and Mill Street, respectively). Area, 28.20 acres in fee.	John H. Livingston, Isaac Gilmour *et al.*	Mar. 8.	Clinton sewerage.
72	Arlington Heights (between Cedar Avenue and Park Avenue). Area, 0.115 acre in fee.	Town of Arlington.	Mar. 11.	Arlington Standpipe and pipe lines.
73	Marlborough (on Farm and Parmenter streets). Area, 91.57 acres in fee.	M. Evelyn Temple, Ann E. Golbert *et al.*	Mar. 14.	Sudbury Reservoir.
74	Southborough (northeasterly part on Marlborough boundary line). Area, 29.18 acres in fee.	Ann E. Golbert *et al.*	Mar. 13.	Sudbury Reservoir.
75	Marlborough (on Southborough and Northborough boundary lines). Area, 15.05 acres in fee.	John A. Gilmore.	Mar. 14.	Wachusett Aqueduct.
76	Southborough and Northborough (on Marlborough boundary line). Area, 0.40 acre in fee.	John A. Gilmore.	Mar. 14.	Wachusett Aqueduct.
77	Stoneham (Woodland Road and Pond Street). Area, 12.93 acres in fee.	Elizabeth H. Moffitt *et al.*	Mar. 14.	Spot Pond improvement.
78	Marlborough (southeasterly from Farm Street). Area, 9.8 acres in fee.	William Barnes.	Mar. 19.	Sudbury Reservoir.
79	Boylston (northeasterly part, southwesterly from Boston & Maine Railroad, Central Massachusetts Division). Area, 4.27 acres in fee.	Alfred G. Larkin.	April 5.	Wachusett Reservoir.
80	Southborough (easterly part, near the Sudbury Dam). Area, 0.81 acre in fee.	Benjamin H. Clemons and Comer A. Belknap.	May 18.	Weston Aqueduct.
81	Framingham, Wayland and Weston (from Southborough line to Sudbury River, and from land of Walter Reeves, in Wayland, to a point a short distance easterly from Wellesley Street, in Weston). Area, 132 70 acres in fee; easements in 8.28 acres; and various rights in 17.41 acres.	Comer A. Belknap *et al.*	May 18.	Weston Aqueduct.
82	Framingham, Wayland and Weston (from Sudbury River easterly to land of Thomas and Anthony Irving, and from land of Irvings to land late of Joseph O. Bullard *et als.*, in Wayland, and from land late of James Cooper southeasterly to Loring Street, in Weston). Area, 79.81 acres in fee; easements in 2.49 acres; and various rights in 12.89 acres.	Charles F. Stone *et al.*	Aug. 31.	Weston Aqueduct.
83	Wayland (on both sides of road from Saxonville to Weston). Area, 6 82 acres in fee; easements in 0.10 acre; and various rights in 0.40 acre.	Thomas and Anthony Irving.	Aug. 31.	Weston Aqueduct.
84	West Boylston and Sterling (north of Oakdale Station, between Pleasant Street and North Main Street, mostly covered by waters of mill pond). Area, 164 40 acres in fee.	West Boylston Manufacturing Company *et al.*	Oct. 9.	Wachusett Reservoir.

Of all the land taken or acquired by the Board for the Metropolitan Water Works since the beginning of operations, aside from the works of Boston, Malden, Medford and Melrose, settlements have been effected with the owners of all but 930.063 acres.

In by far the larger part of the cases, purchases of the territory had been made prior to the taking, and the territory purchased, as well as that not purchased, was embraced in the takings made.

Settlements under such purchases and takings for all purposes of the Water Works have been effected in the past year in 65 cases, and for an aggregate of 495.71 acres with the buildings thereon. The sums paid in these settlements have amounted to $151,697.85. In only 3 of these cases have the settlements been results of suits at law, and the total amount paid in the court settlements has been $11,315.57.

Since the beginning of operations upon the Metropolitan Water Works the number of settlements of this kind effected for the purposes of the Water Works has amounted to 655, and under them the Board has acquired rights, in fee or in easement, in 10,875.84 acres, or 17 square miles, for which an aggregate of $3,456,116.05 has been paid. Only 9 of these cases have been settled by suits at law, and the total amount paid under judgments of the court has been $32,753.04, or less than 1 per cent. of the whole.

These purchases and takings include lands taken in fee with the buildings thereon, and water and other rights connected therewith, and lands in which easements and other rights are taken; but they do not include settlements for diversion of water, depreciation and other damages connected with lands not acquired, and in which no fee or easement has been taken.

Summary of Land Settlements for Water Works to December 31, 1901.

LOCATION.	FOR THE YEAR 1901.			FROM BEGINNING OF WORK.		
	Area in Acres.	Number of Settlements.	Payments.	Area in Acres.	Number of Settlements.	Payments.
*Wachusett Reservoir.**						
Clinton, . . .	26.16	32	$116,493 11	1,184.32	335	$2,535,340 18
Boylston, . . .	70.69			3,561.93		
West Boylston, . .	157.86			1,476.96		
Sterling, . . .	100.43			661.91		
Lancaster, . . .	–			69.97		
Holden, . . .	–			167.00		
Total, . . .	355.14	32	$116,493 11	7,122.09	335	$2,535,340 18

* Including payments on account of St. John's Catholic Cemetery.

Summary of Land Settlements for Water Works to December 31, 1901 — Concluded.

LOCATION.	FOR THE YEAR 1901.			FROM BEGINNING OF WORK.		
	Area in Acres.	Number of Settlements.	Payments.	Area in Acres.	Number of Settlements.	Payments.
Wachusett Aqueduct.						
Berlin,	-	1	$500 00	46.51	61	$69,212 40
Boylston,	-			.38		
Northborough,	-			82.56		
Southborough,	.95			77.31		
Marlborough,	-			50.62		
Clinton,	-			13.51		
Total,	.95	1	$500 00	270.89	61	$69,212 40
*Sudbury Reservoir.**						
Southborough,	-	-	-	1,995.58	150	$658,318 75
Marlborough,	-			750.98		
Total,	-	-	-	2,746.56	150	$658,318 75
Improving Sudbury Watershed.						
Northborough,	12.49	4	$758 00	127.01	32	$11,699 10
Southborough,	-			2.66		
Westborough,	1.00			202.48		
Ashland,	-			.63		
Marlborough,	-			.74		
Total,	13.49	4	$758 00	333.52	32	$11,699 10
Clinton Sewerage System.						
Clinton,	.64	10	$2,540 00	4.65	30	$20,501 50
Lancaster,	.52			81.73		
Total,	1.16	10	$2,540 00	86.38	30	$20,501 50
Weston Aqueduct.						
Weston,	78.71	16	$30,406 74	222.07	23	$58,060 24
Framingham,	44.35			62.35		
Wayland,	1.60			1.60		
Total,	124.66	16	$30,406 74	286.02	23	$58,060 24
Distribution System.						
Boston,	-	2	$1,000 00	.70	24	$102,983 88
Brookline,	-			.05		
Arlington,	-			1.80		
Malden,	-			.16		
Medford,	-			2.39		
Newton,	-			.06		
Quincy,	-			5.23		
Stoneham,	.31			19.99		
Total,	.31	2	$1,000 00	30.38	24	$102,983 88
Aggregates,	495.71	65	$151,697 85	10,875.84	655	$3,456,116 05

* Including settlements made by city of Boston.

(10) Claims and Settlements for Loss of Business.

Additional claims for injury to business by the carrying out of the Metropolitan Water Act in the towns of West Boylston and Boylston, and in a portion of the town of Sterling, have been filed during the year ending December 31, 1901, to the number of 28. Settlements of such claims have been effected during the year in 48 cases, under which the sum of $10,337 has been paid. The total number of claims of this class settled has been 207, in which a total sum of $52,267 has been paid. Claims to the number of 15 have been disallowed during the year, but the votes disallowing 2 of the claims were reconsidered, and settlements thereon effected.

Chapter 505 of the Acts of the year 1901 provided that any person living within the part of the town of Clinton within the limits of the proposed reservoir should be allowed damages for loss of or injury to business, and under this act 2 additional claims have been filed.

(11) Claims and Settlements for Loss of Employment.

During the year ending December 31, 1901, 236 claims for damages for loss of employment by residents of West Boylston have been filed. Settlements have been made in 169 cases, the amount paid being $34,438.50. During the year 70 claims have been disallowed, and votes previously passed disallowing 4 claims were afterwards reconsidered, and settlements thereon have been made. The whole number of claims filed up to December 31, 1901, has been 550; the total number of settlements effected has been 452, and the total amount paid on account of these claims has been $82,171.41.

(12) Claims and Settlements for Depreciation of Real Estate.

Settlements of claims for injury to real estate in the town of West Boylston, and in portions of the towns of Boylston, Clinton and Sterling, have been effected in 42 cases, and the sum of $16,785 has been paid. The total number of claims of this class settled to December 31, 1901, has been 83, and the total amount paid thereon has been $39,520. In all the remaining cases in West Boylston, in which application has been made for damages by owners of such real estate, offers of settlement have been made by the Board.

(13) CLAIMS OF THE CITIES OF BOSTON, MALDEN, MEDFORD AND MELROSE.

Settlement had been effected with the city of Boston at the time of the last report, by which the entire damages on account of the taking, on January 1, 1898, of the sources of water supply and other property of that city, were fixed at $12,531,000, payable as of November 1, 1900. Of this sum, $5,000,000 had been previously paid on account, leaving due to the city of Boston the sum of $7,531,000, with interest from November 1, 1900, at the rate of 3½ per cent. per annum. By the passage of chapter 453 of the Acts of the year 1901, providing for an additional Metropolitan Water Loan, the Treasurer of the Commonwealth was enabled to make a final settlement of the judgment made in favor of the city. Payments were made to the city of Boston of a total additional sum of $7,768,948.80, which included interest to the amount of $237,925.16 and costs of suit $23.64, the final payment being made on October 29, 1901.

Some negotiations have been had with the authorities of Malden, Medford and Melrose, with a view to the settlement of the claims of these cities on account of the taking of Spot Pond and adjoining lands, with the pumping stations thereon. Offers have been made to these cities, but no settlements have yet been effected, although the sum of $25,000 has been paid to the city of Malden on account.

III. WATER WORKS—MAINTENANCE.

(1) OPERATION OF WORKS.

All the cities and towns included in the Metropolitan Water District were supplied with water from the Metropolitan Works in the year 1901, except Newton and Hyde Park. The cities and towns supplied were Boston, Chelsea, Everett, Malden, Medford, Melrose, Quincy, Somerville, Arlington, Belmont, Nahant, Revere, Stoneham, Swampscott, Watertown and Winthrop. Newton and Hyde Park have as yet received no water from the Metropolitan System, as their own works have been adequate for their supply. The town of Stoneham, which was admitted into the District during the year, was supplied with water from the Wakefield Water Company until October 21, after which date it was supplied from the Metropolitan Works. The Wakefield Water Company supplied to Stoneham a total of 193,400,000 gallons. The city of Medford supplied from local sources 21,200,000 gallons. All the rest of the water supplied during the year, amounting to 36,830,240,000 gallons, was furnished from the Metropolitan Water Works.

(2) STORAGE RESERVOIRS.

There are nine completed storage reservoirs having capacities as follows: —

NAME.	Capacity in Gallons.
Lake Cochituate, including Dudley Pond,	2,242,400,000
Sudbury Reservoir,	7,253,500,000
Framingham Reservoir No. 1,	287,500,000
Framingham Reservoir No. 2,	529,900,000
Framingham Reservoir No. 3,	1,183,500,000
Ashland Reservoir,	1,416,400,000
Hopkinton Reservoir,	1,520,900,000
Whitehall Reservoir,	1,256,900,000
Farm Pond,	167,500,000
Total,	15,858,500,000

The Wachusett Reservoir when completed will have a capacity of 63,068,000,000 gallons.

At the beginning of the year the storage reservoirs contained but slightly more than one-half of their total capacity, and the amount of water decreased until March 4, when the reservoirs contained but about two-fifths of their total capacity. The rains of the succeeding three months caused a rapid filling of the reservoirs, and at no time later in the year were they seriously drawn down.

The various sources of supply furnished to the District an average of about 105,000,000 gallons per day. An average of 64,299,000 gallons per day was drawn from the Wachusett Reservoir through the Wachusett Aqueduct into the Sudbury Reservoir. There was drawn from the Sudbury Reservoir and Framingham Reservoir No. 3 an average of 84,930,000 gallons per day. An average of 5,398,000 gallons per day was drawn from Framingham reservoirs Nos. 1 and 2; an average of 1,489,000 gallons per day was turned into Lake Cochituate, and the remainder conveyed by the Sudbury Aqueduct into the District. An average of 14,890,000 gallons per day was drawn from Lake Cochituate and conveyed to the District through the Cochituate Aqueduct.

(3) DISTRIBUTING RESERVOIRS.

The distributing reservoirs are six in number, and there are two standpipes, of all of which the total capacity is 2,178,780,000 gallons, as follows: —

NAME.	Capacity in Gallons.
Spot Pond,	1,791,700,000
Chestnut Hill Reservoir,	300,000,000
Fells Reservoir,	41,400,000
Mystic Reservoir,	26,200,000
Waban Hill Reservoir in Newton,	13,500,000
Forbes Hill Reservoir in Quincy,	5,100,000
Forbes Hill Standpipe,	330,000
Arlington Standpipe,	550,000
Total,	2,178,780,000

The Chestnut Hill Reservoir is now perhaps more especially to be regarded as an equalizing reservoir. Into all the others of these reservoirs water is pumped, and from them water is supplied by gravity.

These reservoirs are available not only for the purposes of distributing the water supply, but they have an added value in giving a great protection to the District, from the fact that they afford a supply stored within the District, which would be sufficient, when they are full, for about three weeks' consumption, in case the sources of supply were cut off by accident or otherwise.

(4) AQUEDUCTS.

The Sudbury Aqueduct has been in constant service during the year except upon the few days when it was necessary to empty it for the purpose of cleaning. It has conveyed, upon an average, 90,328,000 gallons per day. A considerable portion of the time the aqueduct has been run to the full extent to which it is capable, and great care has been required for the prevention of accidents and overcharging.

The Cochituate Aqueduct has been in use about 307 days, and consequently an opportunity has been had for extensive cleanings and for the making of necessary repairs. It has conveyed, upon an average, 14,890,000 gallons per day.

The Wachusett Aqueduct has required but few repairs during the year, and has been in operation 340 days. The flow through the aqueduct has averaged 64,299,000 gallons per day.

(5) Pumping Stations.

All the water furnished by the Metropolitan Works, with the exception of 102,890,000 gallons taken from the Brookline Reservoir in consequence of repairs to the city of Boston pipe lines, has been pumped at the two Chestnut Hill pumping stations.

Water has been pumped at the low-service station to Spot Pond, and thence pumped again for the northern high service to the Fells Reservoir. The small supply required for the southern extra high service in West Roxbury and for the northern extra high service in Arlington has been pumped respectively at the small stations maintained in West Roxbury and Arlington. The present daily pumping capacity of all the stations is 204,500,000 gallons, and there has been pumped at all the stations during the year an average of 109,610,000 gallons per day.

At the Chestnut Hill high-service station the new Allis engine has pumped more than 80 per cent. of the entire quantity of water pumped at this station. The cost per million gallons of raising water one foot high at this station was $0.03, which was almost the same as in the preceding year, while the total quantity pumped at the station was about two-thirds as great and the cost of coal was $0.57 per ton greater. Two new boilers have been provided to replace boilers installed seventeen years ago.

The three new Holly engines at the Chestnut Hill low-service station have been in successful operation during the year, and have pumped about 71 per cent. of the total amount of water supplied by the Metropolitan Works. The cost per million gallons raised one foot was $0.031.

The new Holly engine at the Spot Pond station has pumped nearly all of the water at this station, at a cost of $0.041 per million gallons for raising water one foot high.

The old engines and boilers at the West Roxbury pumping station have been replaced by others of a larger capacity. The new engines have been in operation about six months, and a saving of between 30 and 40 per cent. in amount of coal burned has been effected. Considerable enlargement has been required at the Arlington pumping station. At the West Roxbury and Arlington stations, owing to the much smaller quantities of water pumped, the cost per million gallons raised one foot high was, respectively, $0.299 and $0.109.

Of the entire quantity of water pumped during the year, — 40,018,920,000 gallons, — 39,774,060,000 gallons were pumped in the three large stations. A saving of $0.82 per million gallons pumped has been effected this year from the cost of last year. The reduction in cost has been largely brought about not only by the discontinuance of most of the smaller stations, but by the introduction of more economical machinery and methods at the few large stations. The cost of pumping per million gallons, of $9.64 in the year 1897, has been reduced to $2.52 in the year 1901.

(6) CLINTON SEWERAGE AND FILTRATION WORKS.

The Clinton sewerage and filtration works have been in operation during the entire year, and the amount of sewage pumped and filtered has exceeded by more than one-third the amount so disposed of during the previous year. The cost per million gallons raised one foot high by the pumping engine at the pumping station was $0.18. The cost per million gallons of water filtered at the filter-beds was $8.39.

(7) SANITARY INSPECTION AND REGULATIONS.

The work of inspecting the Cochituate, Sudbury and Wachusett watersheds for the purpose of securing proper sanitary conditions and preventing pollution of the water and contamination from infectious diseases has been continued during the year. The work of the sanitary inspector and his assistant has been devoted largely to these watersheds, though they have to a considerable extent assisted the medical inspector in attention to the Wachusett Reservoir site, which is under the supervision of the engineers having charge of the works of construction.

The number of premises in the Sudbury and Cochituate watersheds recorded as inspected has been 981, but this number does not include a large number of premises which were found on inspection to be in satisfactory sanitary condition. Of the unsatisfactory cases, 162 were remedied by sewer connection, and 160 old cesspools were abandoned. In 10 other cases a complete remedy has been effected, and in 14 a partial remedy only.

In several towns the local boards of health have actively co-operated in compelling owners along the line of sewers to make connections with them.

The results have been a very marked improvement effected in the sanitary condition of the watersheds. The unsatisfactory condition along the line of Marlborough Brook, which empties into the Marlborough filter-beds, has, however, continued, but it is understood that measures are in progress by the city of Marlborough for a radical remedy of the troubles.

Upon the consolidation of the Metropolitan Water Board and Sewerage Commission, it was deemed advisable to readopt the rules made by the State Board of Health for the sanitary protection of the waters used by the Board for water supply, and to readopt and republish the special regulations made by the Board under them in regard to fishing, boating and ice cutting. The Board has also republished and called especial attention in the Wachusett watershed to Rule 4 of the rules of the State Board of Health, prohibiting the discharge of house slops, sink waste, water used for washing or cooking, or other polluted water, into any waters used by the Board as a source, or for the conveyance, storage or distribution of the water supply.

IV. WATER WORKS—FINANCIAL STATEMENT.

(1) Metropolitan Water Loan, Receipts and Assessments.

The appropriations for the construction and acquisition of the Metropolitan Water Works, the receipts which are added to these appropriations, the expenditures for the construction and acquisition of works, and the balances available on January 1, 1902, have been as follows: —

Appropriation under chapter 488 of the Acts of 1895, . . .	$27,000,000 00
Appropriation under chapter 453 of the Acts of 1901, . . .	13,000,000 00
	$40,000,000 00
Proceeds from the sales of property applicable to the construction and acquisition of works (of which $9,690.94 is for the year 1901), ...	31,107 58
	$40,031,107 58
Amount approved by the Metropolitan Water Board and the Metropolitan Water and Sewerage Board for payments to December 31, 1901 (of which $9,404,915.19 is for the year 1901), .	29,432,332 03
Balance January 1, 1902, ...	$10,598,775 55

The Treasurer of the Commonwealth, under the authority given him to issue from time to time, on the request of the Board, negotiable bonds to an amount not exceeding $40,000,000, to be designated the "Metropolitan Water Loan," has sold bonds as follows: —

DATE.	Bonds sold.	Rate (Per Cent.).	Time (Years).	Price.	Premiums (in Amount).
1895, . . .	$2,225,000	3½	40	$110 67	$237,407 50
1896, . . .	2,775,000	3½	40	110 67	296,092 50
1896, . . .	2,000,000	3½	39	106 76268	135,253 60*
1897, . . .	6,000,000	3½	38½	107 82	469,200 00
1898, . . .	2,000,000	3½	40	113 176	263,520 00
1898, . . .	2,000,000	3½	40	112 877	257,540 00
1899, . . .	3,000,000	3	40	100 64	19,200 00
1900, . . .	1,000,000	3	39	102 78	27,800 00
1901, . . .	3,000,000	3	40	102 78	83,400 00
1901, . . .	100,000	3	40	100 375	375 00
1901, . . .	150,000	3	40	100 10	150 00
1901, . . .	205,000	3	39½	100 25	512 50
1901, . . .	50,000	3	39½	100 25	125 00
1901, . . .	50,000	3	39½	100 50	250 00
1901, . . .	300,000	3	39½	100 10	300 00
1901, . . .	200,000	3	39½	100 25	500 00
1901, . . .	3,100,000	3½	39½	106 71	208,010 00
1901, . . .	1,345,000	3	39½	100 00	–
1901, . . .	1,500,000	3	39½	100 00	–
	$31,000,000				$1,999,636 10

* Including $18,673.60 from readjustment of rate made by the Treasurer in 1897.

The sinking fund established by the Treasurer of the Commonwealth has amounted at the end of each year to sums as follows: —

December 31, 1895, ...	$226,286 05
December 31, 1896, ...	699,860 70
December 31, 1897, ...	954,469 00
December 31, 1898, ...	1,416,374 29
December 31, 1899, ...	1,349,332 97
December 31, 1900, ...	1,573,619 72
December 31, 1901, ...	1,662,426 95

From the beginning of the work until June 30, 1901, payments for the maintenance and operation of the works were made from the loan fund, and miscellaneous receipts were credited to the same fund, inasmuch as, according to the original Water Act, the amount to be assessed each year upon the District was limited, and the amount was not in any year sufficient for the payment of maintenance and operation expenses in addition to the interest and sinking fund requirements.

Chapter 489 of the Acts of 1901, however, provided that thereafter assessments should be made each year upon the cities and towns of the District, sufficient for the entire payment of interest, sinking fund requirements and the maintenance and operation of the works for the year. In accordance with the provisions of this Act, the State Treasurer has transferred to the loan fund the amount which had from time to time been paid from it for maintenance and operation, and has also applied the receipts for the year, as required by the provisions of the original Water Act, in part to the loan fund and in part to the sinking fund, and has, also, transferred to the sinking fund certain receipts which had originally been credited to the loan fund.

Allowances for water furnished from their own sources by cities and towns during the year ending May 31, 1901, were made, in accordance with the Metropolitan Water Act, as follows: —

Medford,	$254 40
Stoneham,	954 00

After deducting these allowances, the net assessments for the year 1901, made by the Treasurer of the Commonwealth, for the payment of the interest on the bonds issued by the Commonwealth, the sinking fund requirements and the expenses of operation and maintenance of the water works, were as follows: —

Arlington,	$8,419 30
Belmont,	4,264 90
Boston,	1,169,105 62
Chelsea,	29,570 40
Everett,	21,731 22
Hyde Park,	1,992 40
Malden,	30,548 40
Medford,	18,022 59
Melrose,	12,546 32
Nahant,	2,577 98
Newton,	$6,829 01
Quincy,	22,004 38
Revere,	10,051 21
Somerville,	56,816 76
Stoneham,	4,710 91
Watertown,	9,800 16
Winthrop,	6,217 85
	$1,415,209 41

The comparatively smaller sums assessed upon the city of Newton and the town of Hyde Park were owing to the fact that neither of these municipalities had reached the safe capacity of its sources, and consequently neither had been furnished with water.

The proceeds from the operations of the Board, exclusive of the proceeds from sales of property, have been, according to the provisions of the Water Act, applied to the payment of interest and sinking fund requirements and the maintenance and operation of works, as follows: —

For the year 1901, ...	$21,372 76

The expenditures for the maintenance and operation of the Metropolitan Water Works have been as follows: —

For the year 1901, ...	$304,835 24

Sums have been received during the year 1901, under the provision of the Metropolitan Water Act, in payment for admission to the District and for water furnished, as follows: —

Stoneham, for admission to District, ...	$30,000 00
Swampscott, for water furnished, ...	2,500 00
Revere Water Company, for water furnished, . . .	12,204 29
Framingham Water Company, for water furnished, . .	302 40
Lexington, for water furnished, ...	259 80
	$45,266 49

At the close of the year, the Treasurer, in accordance with the requirements of the Act, has distributed to the cities and towns of the District, in proportion to the annual assessments theretofore contributed by them, this amount, as follows: —

Arlington, ...	$269 07	Newton, ...	$218 25
Belmont, ...	136 30	Quincy, ...	703 23
Boston, ...	37,362 78	Revere, ...	321 22
Chelsea, ...	945 02	Somerville, ...	1,815 77
Everett, ...	694 50	Watertown, ...	313 20
Hyde Park, ...	63 67	Winthrop, ...	198 71
Malden, ...	976 28	Balance, ...	181 04*
Melrose, ...	400 96		
Medford, ...	584 10		$45,266 49
Nahant, ...	82 39		

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* This amount will remain undistributed until next year.

(2) Expenditures for the Different Works.

The following is a summary of the expenditures made in the various operations for the different works: —

CONSTRUCTION AND ACQUISITION OF WORKS.	For the Year ending December 31, 1901.		From Beginning of Work, and ending December 31, 1901.	
Administration applicable to all parts of the construction and acquisition of the works,		$27,640 88		$174,672 65
Wachusett Dam and Reservoir: —				
Wachusett Dam,	$189,841 42		$460,915 60	
North Dike,	96,238 22		515,046 70	
South Dike,	1,127 51		4,951 69	
Removal of soil,	423,495 97		1,109,004 08	
Relocation of railroads,	8,042 66		14,829 39	
Roads and bridges,	8,738 84		284,977 43	
Real estate,	146,571 30		2,775,531 22	
Damages, real estate not taken, business, and loss of wages,	61,560 50		178,958 41	
Other expenses,	1,462 36	937,078 78	2,593 08	5,341,807 55
Improving Wachusett watershed,		2,000 50		14,803 86
Wachusett Aqueduct,		2,209 10		1,779,520 77
Sudbury Reservoir,		2,004 82		2,922,113 78
Protection of Sudbury supply,		3,247 55		119,662 86
Improving Sudbury watershed,		1,061 10		88,814 96
Protection of Cochituate supply,		2,250 00		9,000 00
Improving Lake Cochituate,		25,338 54		25,338 54
Pipe lines, Dam No. 3 to Dam No. 1,		-		48,471 48
Pipe line, Rosemary siphon,		-		23,142 98
Weston Aqueduct: —				
Aqueduct,	$314,992 23		$336,521 13	
Reservoir,	10,944 30		14,891 80	
Supply pipe lines,	6,335 03		6,767 97	
Real estate, taxes and other expenses,	35,432 82	367,704 88	64,299 18	422,479 58
Distribution system: —				
Low service: —				
Pipe lines and connections,	$6,780 31		$1,467,446 25	
Pumping station, Chestnut Hill,	48,774 30		458,990 46	
Reservoir, Spot Pond,	10,823 97		575,520 19	
Gate-house and connections, Chestnut Hill Reservoir,	8,208 75		65,382 55	
Real estate and other expenses,	1,272 70		79,124 73	
Northern high service: —				
Pipe lines and connections,	54,135 73		438,990 88	
Spot Pond pumping station,	42,356 42		290,282 54	
Fells Reservoir, Stoneham,	837 43		141,370 86	
Bear Hill Reservoir, Stoneham,	22,940 71		23,453 27	
Real estate and other expenses,	8 85		14,373 85	
Amounts carried forward,	$196,139 17	$1,370,534 65	$3,554,935 58	$10,969,828 51

CONSTRUCTION AND ACQUISITION OF WORKS.	For the Year ending December 31, 1901.		From Beginning of Work, and ending December 31, 1901.	
Amounts brought forward,	$196,139 17	$1,370,534 65	$3,554,985 58	$10,969,828 51
Distribution system — *Con.*				
Southern high service: —				
Pipe lines and connections,	1,713 67		502,532 78	
Pumping station, Chestnut Hill,	1,253 19		241,750 61	
Forbes Hill Reservoir, Quincy,	40,196 96		68,675 37	
Waban Hill Reservoir, Newton,	1,562 11		1,562 11	
Real estate and other expenses,	5 00		10,222 84	
Northern extra high service,	876 61		12,856 12	
Southern extra high service,	11 67		380 30	
Glenwood Pipe Yard,	82 97		33,109 59	
Chestnut Hill Pipe Yard,	1,836 00	243,677 35	11,063 96	4,437,139 28
Diversion of water, south branch of Nashua River,*	. . .	46,132 50		1,087,087 89
Examination of existing water works and payments on account of same: — †				
To Boston,	$7,768,948 80		$12,768,948 80	
To Malden (on account),	-		25,749 71	
To Newton,	-		60,000 00	
	$7,768,948 80		$12,854,698 51	
Transfers of engines, boilers and other property from works purchased to other portions of the work and included in the above accounts,	-		20,558 65	
			$12,834,139 86	
Engineering, conveyancing, etc.,	877 61	7,769,826 41	24,107 60	12,858,247 46
Pipes, valves, etc., sent to store yard and not yet transferred to works,		-		80,028 89
		$9,430,170 91		
Less value of pipes, valves, etc., purchased and sent to store yards in previous years, but transferred to works, and included in cost of same for current year,		25,255 72		-
Total for constructing and acquiring of works,		$9,404,915 19		$29,432,332 03

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* Of the total expenditures from the beginning of the work, the sum of $124,304.57 is for Clinton sewerage system.

† In addition to the amounts paid for existing water works, the city of Boston was reimbursed the sum of $1,154,766.84 for moneys paid by said city in connection with the building of the reservoir in Southborough (now Sudbury Reservoir), as provided by section 16 of the Metropolitan Water Act, and this amount is included in the cost of Sudbury Reservoir and the protection of Sudbury supply.

MAINTENANCE AND OPERATION.	For the Year ending December 31, 1901.		From Beginning of Work, and ending December 31, 1901.	
Administration,		$7,933 57		$31,810 81
General supervision,		4,335 90		10,487 57
Taxes and other expenses,		26,378 87		47,480 14
Wachusett Reservoir Department: —				
Sanitary inspection,	$39 44		$39 44	
Buildings,	569 99		569 99	
Reservoir,	331 17	940 60	331 17	940 60
Wachusett Dam and Aqueduct Department: —				
General superintendence,	$1,658 55		$6,861 43	
Dam and aqueduct,	7,163 18		28,077 28	
Clinton sewerage system: —				
Pumping station,	2,233 18		5,195 55	
Sewers,	2,499 26		4,795 86	
Sanitary inspection,	394 20	13,948 37	1,269 34	46,199 46
Sudbury Department: —				
General superintendence,	$6,361 19		$25,214 73	
Superintendence, Framingham office,	6,757 22		23,175 39	
Sudbury Reservoir,	8,274 66		29,462 55	
Ashland Reservoir,	1,903 08		6,602 50	
Hopkinton Reservoir,	2,081 91		9,186 67	
Whitehall Reservoir,	242 21		1,413 47	
Framingham Reservoirs 1, 2 and 3,	5,296 73		19,725 38	
Lake Cochituate,	2,731 75		11,747 84	
Marlborough Brook filters,	3,354 66		6,635 23	
Pegan filters,	2,676 04		11,340 45	
Sudbury and Cochituate watersheds,	611 02		1,731 72	
Sanitary inspection,	2,308 97		9,673 45	
Sudbury and Cochituate Aqueducts,	18,342 15		70,251 90	
Chestnut Hill Reservoir,	13,169 23		48,316 87	
Biological laboratory,	3,177 66	77,288 48	13,867 40	283,345 55
Distribution Department: —				
Superintendence,	$12,465 87		$27,351 91	
Arlington pumping station, pumping service,	3,371 03		6,737 74	
Chestnut Hill high-service pumping station, pumping service,	40,611 50		175,774 31	
Chestnut Hill low-service pumping station, pumping service,	39,540 80		59,069 17	
Spot Pond pumping station, pumping service,	13,012 55		26,704 13	
West Roxbury pumping station, pumping service,	9,552 74		19,097 13	
Temporary pumping stations,	731 25		52,979 06	
Arlington standpipe,	119 71		393 93	
Fells Reservoir,	1,544 49		2,907 25	
Mystic Lake, conduit and pumping station,	2,750 64		14,310 11	
Mystic Reservoir,	1,474 71		9,086 20	
Amounts carried forward,	$125,175 29	$130,825 79	$394,410 94	$420,264 13

MAINTENANCE AND OPERATION.	For the Year ending December 31, 1901.		From Beginning of Work, and ending December 31, 1901.	
Amounts brought forward,	$125,175 20	$130,825 79	[illegible]	$420,264 13
Distribution Department — Con.				
Forbes Hill Reservoir,	158 04		158 04	
Spot Pond,	4,101 91		9,947 50	
Waban Hill Reservoir,	2,540 80		3,451 02	
Pipe lines —				
Low service,	18,983 21		82,400 71	
Northern high service,	4,373 94		17,543 12	
Southern high service,	3,282 11		10,382 15	
Buildings at Chestnut Hill,	2,038 26		4,740 01	
Chestnut Hill Pipe Yard,	1,482 76		1,482 76	
Glenwood Pipe Yard and buildings,	5,008 50		10,908 82	
Stables,	6,075 40		15,773 44	
Waste prevention,	90 14		90 14	
		174,009 45		551,024 74
Total for maintaining and operating works,		$304,835 24		$971,288 87

(3) DETAILED FINANCIAL STATEMENT.

The Board herewith presents, in accordance with the Metropolitan Water Act, an abstract of the expenditures and disbursements, receipts, assets and liabilities for the year 1901.

(*a*) *Expenditures and Disbursements.*

The total amount of the expenditures and disbursements on account of construction and acquisition of works for the year beginning January 1, 1901, and ending December 31, 1901, is $9,404,915.19; and the total amount from the time of the organization of the Board, July 19, 1895, to December 31, 1901, is $29,432,332.03.

For maintenance and operation the expenditures for the year have been $304,835.24, and from the beginning of the work $971,288.87.

The salaries of the commissioners, and other expenses of administration, have been apportioned to the construction of the works and to the maintenance and operation of the same, and appear under each of those headings.

The following is a division of the expenditures according to their general character: —

GENERAL CHARACTER OF EXPENDITURES.	For the Year ending December 31, 1901.		From Beginning of Work, and ending December 31, 1901.	
I. CONSTRUCTION OF WORKS, AND ACQUISITION BY PURCHASE OR TAKING.				
Administration.				
Commissioners,	$9,300 00		$78,810 27	
Secretary and auditor,	4,289 44		33,320 90	
Clerks and stenographers,	6,298 45		30,456 10	
Legal services,	-		2,859 00	
Travelling,	534 27		1,999 15	
Stationery and printing,	825 84		5,469 66	
Postage, express and telegrams,	328 19		1,669 15	
Furniture and fixtures,	441 94		3,793 75	
Alterations and repairs of buildings,	2,830 89		5,672 03	
Telephone, lighting, heating, water and care of building,	1,156 96		6,566 79	
Rent and taxes, main office,	975 20		1,382 00	
Miscellaneous expenses,	664 20	$27,640 38	3,173 85	$174,672 65
Engineering.				
Chief engineer and department engineers,	$22,275 35		$132,247 20	
Principal assistant engineers,	15,510 24		95,524 88	
Engineering assistants,	98,985 40		668,974 11	
Consulting engineers,	1,000 00		23,187 07	
Inspectors,	26,291 56		162,760 82	
Architects,	1,656 78		25,870 47	
Railroad and street car travel,	2,135 50		20,970 54	
Wagon hire,	5,302 10		25,771 21	
Stationery and printing,	2,510 72		18,876 99	
Postage, express and telegrams,	883 68		5,533 95	
Engineering and drafting instruments and tools,	2,183 24		18,228 52	
Engineering and drafting supplies,	2,281 35		19,592 16	
Books, maps and photographic supplies,	520 67		4,834 84	
Furniture and fixtures,	1,569 60		14,240 58	
Alterations and repairs of building, — main office,	8,883 61		12,725 56	
Alterations and repairs of building, — sub-offices,	1,506 48		2,601 64	
Telephone, lighting, heating, water and care of building, — main office,	3,071 77		11,126 68	
Telephone, lighting, heating, water and care of building, — sub-offices,	1,708 98		10,817 19	
Rent and taxes, — main office,	2,976 00		3,874 35	
Rent of sub-offices and other buildings,	529 50		3,153 74	
Field offices and sheds,	247 65		1,067 70	
Clinton office building,	-		9,866 87	
Unclassified supplies,	850 42		5,756 72	
Miscellaneous expenses,	783 75		7,304 41	
Reimbursement, city of Boston,	-	203,664 35	69,918 69	1,374,826 89
Amounts carried forward,	. . .	$231,304 73		$1,549,499 54

GENERAL CHARACTER OF EXPENDITURES.	For the Year ending December 31, 1901.		From Beginning of Work, and ending December 31, 1901.	
Amounts brought forward,		$231,304 73		$1,549,499 54
Construction.				
Preliminary work (borings, test pits and other investigations): —				
Advertising,	$839 71		$5,365 40	
Labor,	15,774 70		96,756 32	
Professional services, medical services, analyses, etc.,	61 50		687 83	
Travelling,	11 90		1,644 78	
Rent,	-		37 00	
Water rates,	-		2,077 30	
Freight and express,	41 32		450 58	
Jobbing and repairing,	54 63		476 20	
Tools, machinery, appliances and hardware supplies,	449 63		15,806 74	
Casting, ironwork and metals,	39 26		175 57	
Iron pipe and valves,	156 32		3,230 08	
Blasting supplies,	4 56		41 29	
Paint and coating,	1 44		139 98	
Fuel, oil and waste,	435 87		983 80	
Lumber and field buildings,	1,689 48		6,478 74	
Drain pipe,	-		40 80	
Brick, cement and stone,	14 62		237 81	
Sand, gravel and filling,	74 40		209 45	
Municipal and corporation work,	-		44 07	
Unclassified supplies,	127 29		1,209 89	
Miscellaneous expenses,	10 00		249 69	
Reimbursement, city of Boston,	-	19,786 03	55,404 63	191,748 85
Contracts, Wachusett Reservoir: —				
Contracts completed and final payments made prior to January 1, 1901,	-		$340,071 53	
Moulton & O'Mahoney, excavating soil and refilling at North Dike, Sect. 4,	$6,140 47		157,130 37	
Nawn & Brock, excavating soil, Sect. 6, and building easterly portion of North Dike,	321,856 01		677,854 36	
Busch Bros., excavating soil, Sect. 6, and building road, West Boylston and Boylston, — $600 due, deducted from estimate September 5, 1900,	-		34,560 63	
Long & Little, excavating soil, Sect. 7, and building part of North Dike,	89,960 47		151,042 36	
Newell & Snowling Construction Co., excavating soil from Sect. 8, and completing westerly portion of North Dike,	32,443 72		32,443 72	
Asa Goddard, surfacing Boylston Street, Sect. 2,	60 00		11,428 95	
Amounts carried forward,	$449,960 67	$251,090 76	$1,404,531 92	$1,741,248 39

GENERAL CHARACTER OF EXPENDITURES.	For the Year ending December 31, 1901.		From Beginning of Work, and ending December 31, 1901.	
Amounts brought forward, ...	$449,960 67	$251,090 76	$1,404,531 92	$1,741,248 89
Construction — Con.				
Contracts, Wachusett Reservoir — *Con.*				
Fred E. Ellis, surfacing Sect. 2, Shrewsbury Road, ...	200 00		10,654 35	
McArthur Bros., Wachusett Dam, . .	157,370 96	607,531 63	159,921 64	1,575,107 91
Contracts, Wachusett Aqueduct: —				
Contracts completed and final payments made prior to January 1, 1901, . . .	-		$1,197,506 07	
Silvio Casparis, covered masonry, Sect. 5, .	$600 00		101,179 99	
Silvio Casparis, covered masonry, Sect. 6, .	469 00	1,069 00	148,522 49	1,447,208 55
Contracts, Sudbury Reservoir: —				
Contracts completed and final payments made prior to January 1, 1901, . . .	-		$1,963,732 76	
Auguste Saucier, filter-beds, ...	. . .	3,227 50	42,384 83	2,006,117 59
Contracts, improving Lake Cochituate: —				
Long & Little, excavation from Snake Brook Meadow, ...	. . .	10,236 80		10,236 80
Town of Framingham, low-level sewer, protection Cochituate supply, ...	. . .	2,250 00		9,000 00
Contracts, Rosemary siphon: —				
Contracts completed and final payments made prior to January 1, 1901, . . .	-			5,916 96
Contracts, pipe line, Dam No. 3 to Dam No. 1: —				
Contracts completed and final payments made prior to January 1, 1901, . . .	-			17,240 22
Contracts, Clinton sewerage system: —				
Contracts completed and final payments made prior to January 1, 1901, . . .	-			66,878 22
Contracts, Weston Aqueduct: —				
Shanahan, Casparis & Co., . . Sect. 2,	$39,563 22		$39,563 22	
Shanahan, Casparis & Co., . . Sect. 3,	23,206 62		23,206 62	
Patrick McGovern, ... Sect. 4,	43,463 46		43,463 46	
Bruno, Salomone & Petitti, . . Sect. 5,	43,758 04		43,758 04	
Shanahan, Casparis & Co., . . Sect. 6,	20,489 84		20,489 84	
Winston & Co., . . Sects. 8 and 10,	9,648 26		9,648 26	
Shanahan, Casparis & Co., . . Sect. 12,	27,384 71		27,384 71	
Columbus Construction Co., . . Sect. 13,	36,017 65		36,017 65	
Winston & Co., ... Sect. 15,	3,326 58	246,858 88	3,326 58	246,858 38
Contracts, Distribution System: —				
Contracts completed and final payments made prior to January 1, 1901, . . .	-		$2,950,044 58	
E. W. Everson & Co., pipe laying, Sect. 19, ...	$200 00		37,042 54	
C. H. Eglee Co., pipe laying, Sect. 29, . .	20,450 12		20,450 12	
The Atlantic Works, sluice gates, . .	43 00		14,438 00	
Amounts carried forward, ...	$20,693 12	$1,122,264 07	$3,021,975 19	$7,125,813 02

GENERAL CHARACTER OF EXPENDITURES.	For the Year ending December 31, 1901.		From Beginning of Work, and ending December 31, 1901.	
Amounts brought forward, ...	$20,688 12	$1,122,264 07	$3,021,975 19	$7,125,812 02
Construction — Con.				
Contracts, Distribution System — *Con.*				
Beckwith & Quackenbush, reservoir and foundation for standpipe at Forbes Hill, .	18,908 12		31,421 17	
Walsh's Holyoke Steam Boiler Works, standpipe at Forbes Hill, ...	768 47		4,529 72	
James E. McCoy, masonry tower, Forbes Hill, ...	11,774 06		11,774 06	
McNeil Bros., high-service pumping station and gate-house, — $1,500 due, deducted from final estimate May 22, 1901, . .	6,273 98		120,681 08	
Holly Manufacturing Co., high-service pumping engine, Spot Pond, . . .	31,264 38		78,139 38	
Norcross Bros., Chestnut Hill low-service pumping station, ...	8,104 16		200,549 82	
Holly Manufacturing Co., Chestnut Hill low-service pumping engine, . . .	35,234 62		151,259 62	
John S. Jacobs & Son, southern gate-house, Chestnut Hill Reservoir, ...	4,374 00		9,974 00	
Norcross Bros., connection chamber Chestnut Hill, ...	1,552 00		1,552 00	
C. H. Eglee Co., Bear Hill Reservoir, . .	16,562 18	155,504 08	16,562 18	
			$3,648,418 21	
Deduct value of pipes, valves, etc., included in above list, transferred to maintenance account December 31, 1900, and shown on page 39, ...	-		3,139 77	3,645,278 44
Additional work: —				
Labor, ...	$17,083 06		$453,201 99	
Professional services, medical services, analyses, etc., ...	443 96		1,450 99	
Travelling, ...	54 08		926 65	
Rent, ...	360 00		2,957 37	
Water rates, ...	712 13		1,318 98	
Freight and express, ...	494 20		8,298 74	
Jobbing and repairing, ...	352 48		6,913 89	
Tools, machinery, appliances and hardware supplies, ...	5,291 52		62,552 44	
Electrical supplies, ...	2,088 49		4,771 50	
Castings, ironwork and metals, . . .	4,422 71		42,904 71	
Iron pipe and valves, ...	4,970 92		42,806 48	
Blasting supplies, ...	-		859 41	
Paint and coating, ...	115 34		3,601 18	
Fuel, oil and waste, ...	110 14		5,670 34	
Lumber and field buildings, ...	768 12		70,827 10	
Drain pipe, ...	314 33		4,488 17	
Brick, cement and stone, ...	1,045 00		12,785 12	
Amounts carried forward, ...	$38,621 47	$1,277,768 15	$726,335 06	$10,771,091 46

GENERAL CHARACTER OF EXPENDITURES.	For the Year ending December 31, 1901.		From Beginning of Work, and ending December 31, 1901.	
Amounts brought forward,	$38,621 47	$1,277,768 15	$726,335 06	$10,771,091 46
Construction — Con.				
Additional work — *Con.*				
Sand, gravel and filling,	550 48		4,683 37	
Municipal and corporation work,	487 50		64,753 87	
Police service,	22,584 46		123,458 62	
Sanitary inspection,	918 00		6,141 61	
Judgments,	2,158 36		7,749 49	
Unclassified supplies,	973 52		7,976 74	
Miscellaneous expenses,	6,250 91		14,552 42	
Reimbursement city of Boston,	-	72,539 65	21,765 87	977,417 05
Legal and expert: —				
Legal services,	-		$4,618 82	
Expert services,	-		475 87	
Court expenses,	$7 00		360 31	
Miscellaneous expenses,	-	7 00	33 35	5,488 35
Real Estate.				
Legal and expert: —				
Legal services,	-		$4,736 31	
Conveyancer and assistants,	$8,094 26		76,973 66	
Experts,	1,520 18		16,895 58	
Appraisers,	1,969 00		15,131 34	
Court expenses,	893 37		2,294 52	
Counsel expenses,	-		43 25	
Conveyancing supplies,	110 33		2,891 00	
Conveyancing expenses,	592 32		4,531 96	
Miscellaneous expenses,	46 25		917 45	
Reimbursement, city of Boston,	-		15,021 25	
Settlements, made by Board,	140,882 28		2,891,757 01	
Settlements, reimbursement, city of Boston,	-		531,606 00	
Judgments,	11,315 57		32,753 04	
Taxes and tax equivalents,	2,029 49		70,128 80	
Care and disposal,	15,208 11	182,161 16	38,056 75	3,703,737 92
Damages to Real Estate not taken, to Business, and on Account of Loss of Wages.				
Legal and expert: —				
Legal services,	-		$1,130 67	
Court expenses,	$1,453 86		1,453 86	
Settlements,	61,560 50	63,014 36	173,958 41	176,542 94
Claims on Account of Diversion of Water.				
Legal and expert: —				
Legal services,	-		$3,774 98	
Expert services,	$1,496 47		13,230 64	
Court expenses,	2,843 79		2,343 79	
Miscellaneous expenses,	875 81		1,173 91	
Settlements,	35,000 00	39,716 07	917,350 00	937,873 32
Amounts carried forward,		$1,635,206 39		$16,572,151 04

GENERAL CHARACTER OF EXPENDITURES.	For the Year ending December 31, 1901.		From Beginning of Work, and ending December 31, 1901.	
Amounts brought forward,		$1,635,206 39		$16,572,151 04
Purchase of Existing Water Works.				
Legal and expert:—				
Legal services,	-		$1,878 89	
Expert services,	$760 00		2,650 65	
Miscellaneous expenses,	-		952 94	
Settlements and judgments,	7,768,948 80	7,769,708 80	12,854,698 51	12,860,180 99
Total amount of construction expenditures,		$9,404,915 19		$29,432,332 03
II. MAINTENANCE AND OPERATION OF WORKS.				
Administration:—				
Commissioners,	$1,200 00		$8,400 00	
Secretary, auditor and assistants,	3,673 07		16,994 06	
Postage, printing, stationery and other supplies,	676 86		1,811 48	
Travelling,	223 96		606 92	
Telephone, heating, lighting and care of building,	486 29		1,901 49	
Alterations and repairs of building,	1,380 62		1,450 62	
Rent and taxes, office building,	165 00		295 60	
Miscellaneous expenses,	127 77		350 64	
Supervision and general superintendence:—				
Chief engineer and department engineers,	8,524 65		27,188 32	
Engineering and clerical assistants,	7,907 96		26,531 10	
Postage, printing, stationery and office supplies,	1,374 71		3,069 49	
Telephone, heating, lighting and care of offices,	1,309 21		4,069 05	
Travelling and incidental expenses,	451 00		1,996 12	
Alterations and repairs of buildings,	4,186 83		5,259 85	
Rent and taxes, main office,	495 00		719 59	
Miscellaneous expenses,	572 15		1,062 12	
Pumping service:—				
Labor,	50,500 85		138,671 55	
Fuel,	44,057 91		123,494 50	
Oil, waste and packing,	1,937 88		5,302 32	
Repairs and renewals,	5,839 43		16,745 31	
Small supplies and expenses,	3,519 05		8,989 31	
Pumping by municipalities,	-		45,278 80	
Rent, West Roxbury pumping station,	920 00		1,840 00	
Superintendents and assistant superintendents,	3,543 43		11,956 76	
Engineering assistants,	7,295 17		27,942 58	
Laboratory force,	2,354 61		10,315 98	
Sanitary inspectors,	2,414 44		9,641 12	
Recording and scientific instruments and supplies,	529 82		2,159 00	
Labor and teaming,	85,224 73		278,703 19	
Tools, machinery and appliances,	1,451 40		7,167 57	
Lumber and hardware supplies,	2,371 12		8,165 67	
Jobbing and repairing,	1,626 69		7,669 17	
Amounts carried forward,	$246,341 61		$805,764 28	

GENERAL CHARACTER OF EXPENDITURES.	For the Year ending December 31, 1901.		From Beginning of Work, and ending December 31, 1901.	
Amounts brought forward,	$246,841 61		$805,764 28	
MAINTENANCE, ETC. — *Con.*				
Travelling,	3,219 12		9,768 30	
Horses, vehicles and stable expenses,	3,387 71		18,326 02	
Fuel, lighting and telephone,	2,976 38		10,076 59	
Municipal and corporation work,	288 12		3,838 79	
Alterations and repairs of buildings,	-		402 97	
Settlements of claims,	-		1,000 00	
Unclassified supplies,	5,191 62		15,600 46	
Miscellaneous expenses,	1,402 07		4,326 96	
Conveyancer and assistants,	50 85		352 85	
Taxes and tax equivalents,	26,324 90		47,124 17	
Contracts and agreements,	12,870 09		53,784 94	
Contracts for pipes, valves, etc., bought from construction work since January 1, 1901,	2,782 77		2,782 77	
Contracts for pipes, valves, etc., originally charged to construction, transferred to maintenance previous to January 1, 1901 (included in list, pages 35–36),	-		3,189 77	
Total expenditures for maintenance and operation,		$304,835 24		$971,288 87

(*b*) *Receipts.*

The total amount of receipts from rents, sales of property, etc., for the year beginning January 1, 1901, and ending December 31, 1901, is $76,330.19; and the total amount from the time of the organization of the Board, July 19, 1895, to December 31, 1901, is $214,716.56. The general character of these receipts is as follows: —

GENERAL CHARACTER OF RECEIPTS.	For the Year ending December 31, 1901.		From Beginning of Work, and ending December 31, 1901.	
For distribution back to District: —				
District entrance fees,	$30,000 00		$65,005 00	
Supplying water outside of District,	2,759 80		25,405 64	
Water furnished to water companies,	12,506 69	$45,266 49	17,878 27	$108,288 91
To the credit of the loan fund: —				
Real estate and buildings,	$4,377 09		$9,870 00	
Labor, tools and supplies,	5,313 85	9,690 94	21,237 58	31,107 58
To the credit of the sinking fund: —				
Forfeiture for contracts awarded but not executed,	-		$500 00	
Rents,	$16,241 41		59,813 04	
Land products,	5,080 76		14,682 04	
Unclassified receipts,	50 59	21,372 76	324 99	75,320 07
Total receipts,	. . .	$76,330 19		$214,716 56

The foregoing receipts have been credited to the various objects or works, as follows: —

RECEIPTS FROM DIFFERENT WORKS.	For the Year ending December 31, 1901.		From Beginning of Work, and ending December 31, 1901.	
Distribution back to District: —				
Admission into Metropolitan Water District (Nahant, Quincy and Arlington), . .	$30,000 00		$65,005 00	
Supplying water to towns outside of Water District (Swampscott and Lexington), .	2,759 89		25,406 64	
Water furnished to water companies, . .	12,506 60	$45,266 49	17,878 27	$108,288 91
Construction and acquisition of works: —				
Administration, ...	$90 75		$90 75	
Wachusett Dam, ...	297 00		452 00	
Wachusett Reservoir, ...	18,772 87		67,168 36	
Wachusett Aqueduct, ...	233 83		504 95	
Weston Aqueduct, ...	1,120 51		1,120 51	
Sudbury Reservoir and watershed, . .	727 20		7,249 20	
Distribution system, ...	7,062 73		16,476 05	
Diversion of water, Clinton sewerage system,	10 00		656 91	
Purchase of existing water works, . .	796 87	29,110 76	5,288 12	98,916 94
Maintenance and operation of works: —				
Wachusett Aqueduct, ...	$435 00		$1,582 11	
Sudbury system, ...	906 66		4,023 28	
Distribution system, ...	118 90		1,216 88	
Clinton sewerage system, ...	492 38	1,952 94	688 44	7,510 71
Total receipts, ...	. . .	$76,330 19		$214,716 56

(c) *Assets.*

The following is an abstract of the assets: —

Office furniture, fixtures and supplies: —

46 book cases; 46 plan cases; 87 miscellaneous cases and cabinets; 382 chairs; 133 desks; 22 letter-copying presses; 7 numbering machines; railroad tickets (value), $2,116.04; 534 reference books; 168 stools; 66 coal stoves; 93 tables (office); 45 tables (drafting); 17 telephones; 20 typewriters; stamped envelopes (value), $970.67.

Engineering and scientific instruments and supplies: —

1 biological laboratory outfit; 1 chemical laboratory outfit; 106 drawing boards; 8 calculating instruments; 6 cement-testing machines; 3 current meters; 5 electrical instruments; 28 engineers' levels; 3 pantographs; 1 photographic outfit; 24 planimeters; 185 levelling, measuring and sight rods; 211 rubber boots, pair; 266 scales; 4 section liners; 74 straight-edges; 225 tapes; 4 transverse testing machines; 28 transits.

Police supplies: —

23 belts; 9 cells; 33 clubs; 12 beds; 31 pair handcuffs; 7 revolvers; 28 pair twisters; 2 stretchers.

Horses, vehicles, field machinery, etc.: —

19 horses; 9 carriages; 10 carts; 6 sleds; 14 sleighs; 17 wagons; 3 harrows; 3 mowing machines; 12 ploughs; 3 horse rakes; 4 road rollers; 2 road scrapers; 2 tedders; 51 blankets; 32 harnesses; 26 robes; 283 bush hooks, bill hooks, scythes, etc.; 6 hand carts; 43 border knives, hedge trimmers, etc.; 11 lawn mowers.

Machinery, tools and other appliances and supplies: —

5 adzes; 9 anchors; 12 anvils; 209 axes and hatchets; 132 barrows; 210 bars, crow and others; 2 blasting batteries; 203 blocks, all kinds; 2 blowers; 17 boats, row; 32 boilers; 2 diamond drills; 74$\frac{1}{32}$K. diamonds for same; 356 chisels; 13 carts and cars; 29 chain hoists; 1 concrete mixer; 14 derricks; 7 dredges, scows, etc.; 24 drilling machines; 5 dynamos; 26 engines; 7 forges; 6 furnaces, melting; 92 gages; 31 grindstones; 171 hoes, all kinds; 152 forks; 395 hammers; 1 heater; 43 hoisting buckets; 5,231 feet hose, all sizes; 138 ice tools; 8 indicators; 8 injectors and inspirators; 52 jacks; 1,309 feet ladders; 4 lathes; 249.5 M feet B. M. lumber; 143 mattocks; 17 mauls; 18 meters, pressure, etc.; 2 motors; 33 oil cabinets and tanks; 3 pile drivers; 21 pipe cutters; 35 die plates, stocks, etc.; 1 pipe-tapping machine; 368 picks; 1 planer; 9 pumping engines; 50 steam pumps; 13 centrifugal pumps; 16 diaphragm pumps; 19 miscellaneous pumps; 231 rakes; 103 rammers; 2 rock drills; 137 saws; 36 scales, yard, platform, etc.; 44 settees, Chestnut Hill grounds; 914 shovels, scoops, spades, etc.; 1 steam shovel; 1 stone crusher; 89 temporary buildings and structures; 130 tongs; 47 tool and coal boxes, etc.; 29 trench and other braces; 4 trucks; 39 vises; 3 winches; 833 wrenches; 10,085 feet wrought-iron pipe, all sizes; 137 tons cast-iron pipe, miscellaneous lots; $70,703.73 cast-iron pipes, special castings, valves, man-hole covers, etc, at pipe yards (estimated value).

Real estate connected with works not completed: —

Real estate in the site of the proposed Wachusett Reservoir and margins; outlying property in Clinton, Boylston, West Boylston and Sterling; land for Weston Aqueduct and Reservoir; and for the partially completed Bear Hill Reservoir, Stoneham.

Completed works, including real estate and buildings connected therewith: —

Wachusett Aqueduct, Sudbury Aqueduct, Cochituate Aqueduct; Whitehall Reservoir, Hopkinton Reservoir, Ashland Reservoir, Framingham Reservoirs Nos. 1, 2 and 3, Sudbury Reservoir, Lake Cochituate, Chestnut Hill Reservoir, Waban Hill Reservoir, Fells Reservoir, Mystic Lake conduit and pumping station (not used), Mystic Reservoir; Forbes Hill Reservoir and standpipe; Arlington standpipe; Chestnut Hill high-service pumping station, Chestnut Hill low-service pumping station, Spot Pond and Spot Pond pumping station, temporary pumping station, Arlington; sewerage system and pumping station, Clinton; 72 miles of pipe line in distribution system; Mystic yard and buildings, Glenwood pipe yard and buildings, Chestnut Hill pipe yard and buildings; Clinton office and grounds.

(*d*) *Liabilities.*

There are liabilities as follows: —

Unpaid bills,	$15,205 00*
Due on monthly pay rolls,	5,270 00
	$20,475 00

Amounts reserved on Monthly Estimates, not due until Completion of Contracts or until Claims are settled.

NAME.	Work.	Amount.
Nawn & Brock,	Wachusett Reservoir, Sect. 6,	$50,000 00
McNeil Bros.,	High-service pumping station, Items 8 and 9,	1,500 00
Busch Bros.,	Building road, Wachusett Reservoir,	600 00
Long & Little,	Wachusett Reservoir, Sect. 7,	23,361 62
Beckwith & Quackenbush,	Reservoir and foundation for standpipe,	5,544 91
McArthur Bros.,	Wachusett Dam,	28,221 47
James E. McCoy,	Masonry water tower,	2,077 77
Shanahan, Casparis & Co.,	Weston Aqueduct, Sect. 2,	6,381 74
Shanahan, Casparis & Co.,	Weston Aqueduct, Sect. 3,	3,865 88
Patrick McGovern,	Weston Aqueduct, Sect. 4,	3,981 79
Bruno, Salomone & Petitti,	Weston Aqueduct, Sect. 5,	7,722 01
Shanahan, Casparis & Co.,	Weston Aqueduct, Sect. 6,	3,368 80
Winston & Co.,	Weston Aqueduct, Sects. 8 and 10,	1,702 64
Shanahan, Casparis & Co.,	Weston Aqueduct, Sect. 12,	4,550 24
Columbus Construction Co.,	Weston Aqueduct, Sect. 13,	6,356 06
Winston & Co.,	Weston Aqueduct, Sect. 15,	587 04
C. H. Eglee & Co.,	Bear Hill Reservoir,	1,158 03
Newell & Snowling Construction Co.,	Wachusett Reservoir, Sect. 8,	5,725 36
Long & Little,	Excavation from Snake Brook Meadow,	1,321 20
		$158,026 56

Amounts have been agreed upon in the following cases, but the deeds have not passed: —

Bruno St. Onge, $4,000; Lizzie W. Thompson, $800; Annie Pendergast, $2,080; Evelyn V. Nolte, $250; heirs of Deborah Ware, $9,283.26; Luther Frank Upham, $75; John A. Frye, $900; Alice C. Davis *et als.*, $75; S. M. & C. B. Cutting,

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* Miscellaneous current bills of 1901, including those coming in from time to time after January 1, 1902, have since been paid.

$4,100; Helen M. Bennett *et als.*, $1,400; A. J. Scarlett *et al.*, $1,000; John Toomey, $12,000; Asia S. Jefts, $1,425; Lucretia B. Lawrence, $8,700; Mary F. Cutting, $4,750; Henry Brown *et als.*, $3,500; E. Lewis Moore, $150; R. E. & W. C. Forbes, $75.

On the claims of the following it is impossible to state the amounts due for land damages and water rights, as suits are now pending in the courts for the determination of the same: —

Patrick T. Moran, Harriet Wilder, Maria A. Haskell, Timothy John Fahy, Chloe Ann Ballou, William H. Buck, estate of Henrietta M. Johnson, Charles L. Johnson, Israel G. Howe, Charles B. Sawin, W. O. Johnson, Jeremiah Potter, J. R. Stott, Horace H. Lowe, Bigelow Carpet Company, Elijah Bemis, Charles E. Nichols, Nellie E. Burke, J. M. Sears, city of Malden, balance city of Medford, city of Melrose, Henry Jackson, Antoine Snow, Sarah E. Kirby, Edward A. Cowee, Joseph Toombs, Cyrus Colt, heirs of Hanson Chase, Boston & Maine Railroad, American Telephone and Telegraph Company, John N. Flagg, George L. Hyde, Edward A. Harper, Thomas Mackesy, Delina Mallett, Independent Order of Odd Fellows, John F. O'Brien, Boston & Albany Railroad Company, Emory A. Bacon, Louis Bond, Ralph H. Hosmer *et als.*, Frances A. Wilder *et al.*, Frances H. Chase, *administratrix*, Nashua River Paper Company, George L. Redding, Michael O'Malley, James Dorr, Charles U. Cotting *et als.*, Hannah McAndrew, Margaret E. Sargent, Framingham Water Company, Charles W. Felt, Johanna T. Dunn, Ida E. Wadsworth.

V. SEWERAGE WORKS — CONSTRUCTION.

The Metropolitan Sewerage Works, both in construction and maintenance, are now divided into two general systems, — the North Metropolitan System and the South Metropolitan System.

(1) North Metropolitan System.

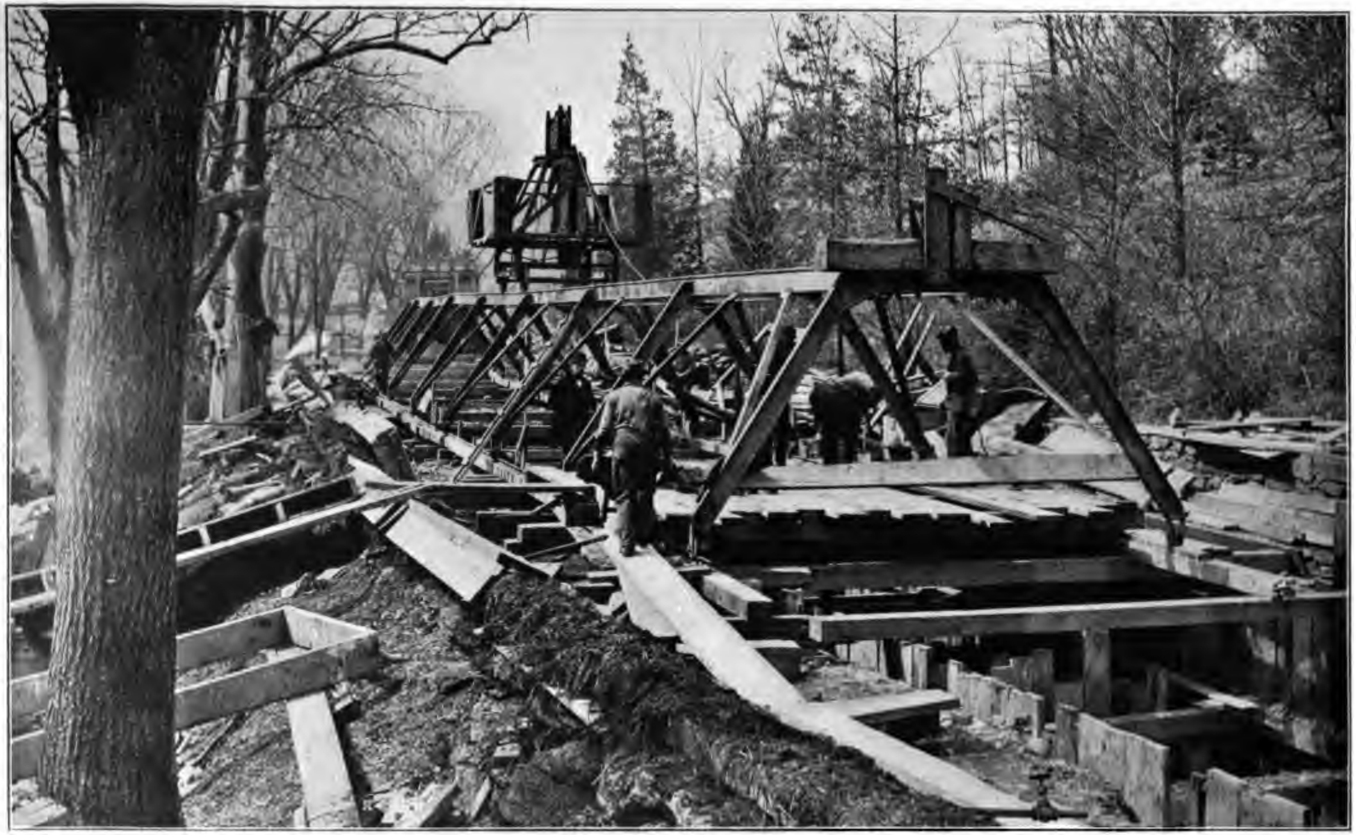
The North Metropolitan System provides for a district which lies wholly north of the Charles River, and has an area of 85 square miles, including the cities and towns of Arlington, Belmont, Cambridge, Chelsea, Everett, Malden, Medford, Melrose, Somerville, Stoneham, Wakefield, Winchester, Winthrop, Woburn, a part of the town of Lexington, and the parts of the city of Boston known as East Boston and Charlestown. These localities are situated in part in the Mystic River valley and in part in the Charles River valley. The district has a population of nearly 450,000, of whom about 325,000 contribute sewage to the system. The Metropolitan sewers constructed in the district are about 55 miles in length. Within the District are operated the Deer Island, East Boston, Charlestown and Alewife Brook (Somerville) pumping stations. The North Metropolitan System, as now contemplated, has been substantially completed.

But little construction was done during the fifteen months beginning with October 1, 1900, and ending with December 31, 1901. A sewer of the length of 1.58 miles was constructed, under the authority of chapter 184 of the Acts of the year 1900, in Chelsea, in order to provide additional outlets for areas in Chelsea and Everett. A length of 3.04 miles of sewer was constructed in accordance with chapter 172 of the same year, which authorized the Board to construct a main trunk sewer through the cities of Malden and Melrose to the line of the town of Wakefield, in order to provide for the part of that town which had not previously been a portion of the Metropolitan area. Considerable difficulty was experienced in the construction of a portion of this sewer, but the work was successfully accomplished in the month of December.

(2) South Metropolitan System.

The South Metropolitan System has an area of 102 square miles, and embraces the cities and towns of Brookline, Hyde Park, Milton, Newton and Quincy, a part of the town of Dedham, and the Brighton district and portions of the Back Bay, Dorchester, Roxbury and West Roxbury districts in the city of Boston, all situated on the south side of the Charles River, together with the city of Waltham and the town of Watertown situated on the north side of that river. These localities are partly in the Charles River valley and partly in the Neponset River valley. The South Metropolitan District has a population of about 280,000, of whom about 110,000, as is estimated, now contribute sewage to the system. The Metropolitan sewers already constructed have a length of 27 miles, and there is one pumping station, that at Quincy. This system is but partially completed.

The provisions of chapter 424 of the Acts of the year 1899 authorized the construction of the high-level sewer, so called, and



HIGH LEVEL SEWER — Construction with Trench Machine in South Street, passing Hemlock Hill.

united the systems formerly known as the Charles River Valley System and the Neponset River Valley System, with other territory, as the South Metropolitan System.

The sewers embraced in the Charles River Valley and Neponset River Valley systems had been constructed prior to the passage of the Act, and it was provided that the sewage received from these two systems and from the additional territory in the city of Quincy, and in the Roxbury, West Roxbury and Dorchester portions of the city of Boston should be conveyed to an outlet into the sea.

The high-level sewer begins at its connection with the old Charles River valley sewer near the proposed Ward Street pumping station, at the foot of the northerly side of Parker Hill in Roxbury, and extends in a southerly direction under Parker Hill, through Jamaica Plain, past the Arnold Arboretum, and, turning thence in a general southeasterly direction, continues through the northeasterly part of Hyde Park, to a connection with the existing Neponset valley sewer, thence passes under the Neponset River, and extends in an easterly direction through the northerly part of Milton to the central part of Quincy, and thence, passing near the Mount Wollaston Cemetery, through Hough's Neck to Nut Island, from which cast-iron outfall pipes, about a mile in length, are to be laid in the bed of the harbor.

The entire length of the high-level sewer will be about 16.81 miles, and the work, for purposes of construction, is divided into 36 contract sections. Previous to October 1, 1900, contracts had been made for the construction of 9 sections, involving a length of about 5.03 miles. The work on a portion of these sections was far advanced, but none of them had been completed at that date. Contracts have since been made for 17 of the remaining sections. The sections remaining to be arranged for are those at Hough's Neck and Nut Island; a section in Milton on the proposed extension of Brook Road or boulevard; the crossing of the Neponset River; the completion of the crossing of Stony Brook (now under construction by day labor); the filling in of special work omitted in Section 70, in West Roxbury; the construction and equipment of the Ward Street pumping station; the laying of two lines of force mains from the pumping station to the Parker Hill tunnel; and the building of a line of sewer to connect the high-level sewer with the existing Charles River Valley System.

The total amount of the contracts already made for the high-level

[illegible]

[illegible]

[illegible]

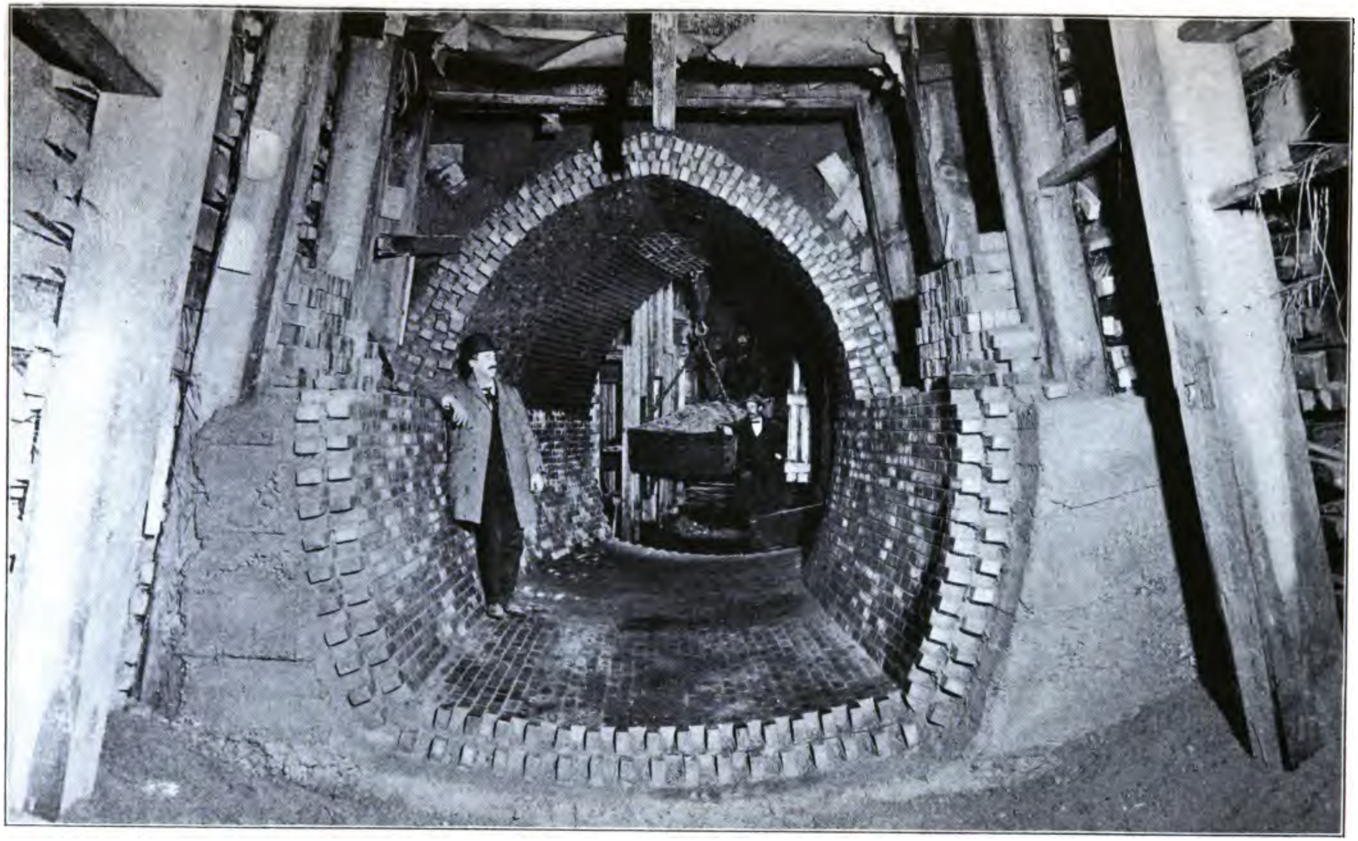
[illegible] of any contract for this sewer was made [illegible].

Chapter 2[illegible] of the Acts of the year 1901 required the Board to make an extension of the Metropolitan sewer from a branch in St. Joseph's Cemetery through lands in West Roxbury and Newton to the Brookline town line, a distance of [illegible] feet. The plan proposed for the extension was submitted in accordance with the Act to the State Board of Health, and was approved by that Board on September 5, 1901. A contract has been made for the construction of this sewer, and about a quarter of the work had been accomplished at the end of the year.

The sewerage construction work carried on during the year 1901 was greater than that in any preceding year since the establishment of the Sewerage Commission, and involved an expenditure, exclusive of maintenance, of upwards of $1,660,000.

(3) Quincy Pumping Station.

In accordance with the provisions of the Act establishing the South Metropolitan System, the pumping station of the city of Quincy was purchased by the Board and transferred to the Commonwealth on April 1, 1901. This station is located near the northerly limit of Merrymount Park. The pumping station contains two engines and other equipment, having a capacity for pumping respectively 3,000,000 gallons and 5,000,000 gallons per day. Included in the purchase of this station were 2¾ acres of land and a cast-iron force main from the station to its junction with the outfall sewer of the Boston main drainage system, a distance of about 3.40 miles.



HIGH LEVEL SEWER—CONSTRUCTION OF TUNNEL IN SAND, FOREST HILLS.

Amount brought forward,	$5,010,865 73
Appropriation under chapter 414 of the Acts of 1896, for Greenwood and Boyntonville (Wakefield),	30,000 00
Appropriation under chapter 88 of the Acts of 1897, for Greenwood and Boyntonville (Wakefield), additional loan,	5,000 00
Appropriation under chapter 436 of the Acts of 1897, for additional outlet in Stoneham,	10,000 00
Appropriation under chapter 520 of the Acts of 1897, for Lexington extension,	70,000 00
Appropriation under chapter 215 of the Acts of 1898, for additional outlet in Everett,	60,000 00
Appropriation under chapter 424 of the Acts of 1898, for additions to existing pumping plants,	155,000 00
Appropriation under chapter 172 of the Acts of 1900, for Wakefield branch,	175,000 00
Appropriation under chapter 184 of the Acts of 1900, for additional outlets in Chelsea and Everett,	90,000 00
	$5,605,865 73
Proceeds from sales of property and from other sources to December 31, 1901,	16,057 53
	$5,621,923 26
Amount approved by the Metropolitan Sewerage Commission and the Metropolitan Water and Sewerage Board for payment to December 31, 1901 (of which $248,433.44 is for the preceding fifteen months),	5,565,707 81
Balance, January 1, 1902,	$56,215 45

(*b*) *South Metropolitan System.*

Charles River Valley Sewer.

Appropriation under chapter 439 of the Acts of 1889 (portion of original loan of $5,000,000 devoted to this system),	$789,134 27
Appropriation under chapter 464 of the Acts of 1900, for siphon purchase in Watertown,	10,912 00
	$800,046 27
Amount approved by the Metropolitan Sewerage Commission for payment to December 31, 1901,	800,046 27
No balance, January 1, 1902,	–

Neponset River Valley Sewer.

Appropriation under chapter 406 of the Acts of 1895, original loan,	$500,000 00
Appropriation under chapter 83 of the Acts of 1897, additional loan,	300,000 00
Appropriation under chapter 180 of the Acts of 1898, additional loan,	35,000 00
Appropriation under chapter 241 of the Acts of 1899, additional loan,	25,000 00
Appropriation under chapter 204 of the Acts of 1901, additional loan,	40,000 00
	$900,000 00
Proceeds from pumping ground water,	109 50
	$900,109 50
Amount approved by the Metropolitan Sewerage Commission and the Metropolitan Water and Sewerage Board for payment to December 31, 1901 (of which $12,607.68 is for the preceding fifteen months),	866,290 16
Balance, January 1, 1902,	$33,819 34

High-level Sewer.

Appropriation under chapter 424 of the Acts of 1899, original loan,	$4,600,000 00
Proceeds from sales of property to December 31, 1901,	575 00
	$4,600,575 00
Amount approved by the Metropolitan Sewerage Commission and the Metropolitan Water and Sewerage Board for payment to December 31, 1901 (of which $1,371,981.64 is for the preceding fifteen months),	1,763,892 58
Balance, January 1, 1902,	$2,836,682 42

(c) *Metropolitan Sewerage Loans Sinking Fund.*

Under authority of chapter 122 of the Acts of 1899, and section 14 of chapter 424 of the Acts of 1899, the Treasurer of the Commonwealth was required to consolidate the sinking funds of all the Metropolitan sewerage loans into one fund, to be known as the Metropolitan Sewerage Loans Sinking Fund.

The sinking fund as thus established has amounted at the end of each year to sums as follows: —

December 31, 1899,	$361,416 59
December 31, 1900,	454,520 57
December 31, 1901,	545,668 26

(2) ANNUAL APPROPRIATIONS AND RECEIPTS.

The annual appropriations for the maintenance of the Metropolitan Sewerage Works, the receipts of the Board which are added to the appropriations for maintenance, and the expenditures for maintenance for the fifteen months ending December 31, 1901, have been as follows: —

North Metropolitan System.

Balance, October 1, 1900,	$51,995 80
Appropriation under chapter 40 of the Acts of 1901,	76,500 00
Receipts from pumping and from other sources,	325 02
	$128,820 82
Amount approved by the Boards for payment,	115,868 15
Balance, January 1, 1902,	$12,952 67

South Metropolitan System.

Balance, October 1, 1900,	$9,447 89
Appropriation under chapter 30 of the Acts of 1901,	76,060 00
Receipts from sales of property and from pumping,	10 00
	$85,517 89
Amount approved by the Boards for payment,	73,998 61
Balance, January 1, 1902,	$11,519 28

The Board has also received from rentals and from other sources, to be applied by the Treasurer of the Commonwealth to the Metropolitan Sewerage Loans Sinking Fund requirements, $318.85.

(3) ANNUAL ASSESSMENTS.

Chapter 424 of the Acts of the year 1899 provided that the Supreme Judicial Court should determine the proportion in which each of the cities and towns of the South Metropolitan System should, for the term of five years next after the year of the first issue of scrip or certificates of debt under said chapter, annually pay money into the treasury of the Commonwealth to meet the interest and sinking fund requirements, and the cost of maintenance and operation of the system. The award of the commission appointed in the year 1900, covering the term of five years beginning with the year 1900 and ending with the year 1904, is shown on pages 32 and 33 of the twelfth annual report of the Metropolitan Sewerage Commission.

Chapter 439 of the Acts of the year 1889 provided in a similar manner for the appointment of commissioners in every term of five years to determine the proportion in which each of the cities and towns forming the North Metropolitan System should annually pay money to meet the interest and sinking fund requirements, and the cost of maintenance and operation of that system. On May 16, 1901, the Supreme Judicial Court appointed James F. Jackson of Fall River, Larkin T. Trull of Lowell and Arthur P. Rugg of Worcester commissioners to determine the amount of these annual payments, beginning with the year 1901 and ending with the year 1905; and the full award of the commissioners will be found in Appendix No. 6.

The proportions in percentages which are determined to be payable by the several cities and towns are as follows: —

CITY OR TOWN.	Proportions in Percentages for Interest and Sinking Fund, based on Valuation.	Proportions in Percentages for Maintenance and Operation, based on Population.
Arlington,	2.39	2.06
Belmont,	1.50	.94
Boston,*	16.89	20.66
Cambridge,	25.75	21.96
Chelsea,	6.20	8.14
Everett,	4.81	5.82
Lexington,†	.90	.32
Malden,	8.16	8.05
Medford,	5.40	4.36
Melrose,	3.41	3.10
Somerville,	13.87	14.74
Stoneham,	1.35	1.48
Wakefield,	2.35	1.78
Winchester,	2.41	1.73
Winthrop,	1.81	1.45
Woburn,	2.80	3.41
Totals,	100.00	100.00

* East Boston and Charlestown districts. † Villages of Centre and East Lexington.

(4) EXPENDITURES FOR THE DIFFERENT WORKS.

The following is a summary of the expenditures made in the various operations for the different works: —

CONSTRUCTION.	For Fifteen Months ending December 31, 1901.		From Beginning of Work to December 31, 1901.	
North Metropolitan System.				
Original system, main line and branches,	$8,728 86		$5,150,782 53	
Lexington branch,	-		68,585 15	
Everett branch,	-		54,877 12	
Wakefield branch,	86 00		35,698 29	
Stoneham branch,	-		11,574 10	
Chelsea and Everett outlets,	65,996 56		67,805 71	
Wakefield branch extension,	173,622 02		176,384 91	
Total, North Metropolitan System,		$248,433 44		$5,565,707 81

CONSTRUCTION.	For Fifteen Months ending December 61, 1901.		From Beginning of Work to December 31, 1901.	
South Metropolitan System.				
Charles River valley sewer,	-			$800,046 27
Neponset River valley sewer, main line,	$3,120 20		$856,802 68	
Brookline branch,	9,487 48		9,487 48	
Total,		$12,607 68		866,290 16
High-level sewer: —				
Section 43, Quincy,	$3,155 75		$8,571 87	
Section 44, Quincy,	2,084 43		6,199 43	
Section 45, Quincy,	943 66		3,625 62	
Section 46, Quincy,	1,115 65		3,797 61	
Section 47, Quincy,	5,761 32		8,443 28	
Sections 48 and 49, embankments, Quincy,	24,453 00		24,453 00	
Section 48, Quincy,	2,288 59		4,970 55	
Section 49, Quincy,	54,807 22		57,489 18	
Section 50, Quincy,	8,201 02		10,882 98	
Section 51, Quincy,	58,555 82		61,237 78	
Section 52, Quincy,	10,197 36		12,879 82	
Section 53, Quincy,	5,766 19		8,448 15	
Section 54, Quincy,	4,832 83		7,514 79	
Section 55, Quincy and Milton,	103,979 15		106,661 11	
Section 56, Milton,	80,429 59		83,111 55	
Section 57, Milton,	5,661 97		8,343 93	
Section 58, Milton,	3,491 32		6,173 28	
Section 59, Milton,	7,482 44		10,164 40	
Section 60, Milton,	1,700 14		4,382 10	
Section 61, Milton,	894 69		3,576 65	
Section 62, Milton,	107,421 08		110,103 03	
Section 63, Milton,	81,736 42		84,418 37	
Section 64, Neponset River crossing,	1,175 33		3,857 28	
Section 65, Hyde Park,	23,086 04		40,503 13	
Section 66, Hyde Park,	92,484 17		114,858 13	
Section 67, Hyde Park, Stony Brook crossing,	4,620 46		7,302 41	
Section 68, Hyde Park and Roxbury,	22,874 24		78,213 66	
Section 69, West Roxbury,	42,315 20		101,861 64	
Section 70, West Roxbury,	61,689 64		86,507 44	
Section 71, West Roxbury,	63,557 67		87,588 67	
Section 72, West Roxbury,	108,562 61		111,251 98	
Section 73, West Roxbury,	36,996 87		39,678 28	
Section 74, West Roxbury and Roxbury,	119,643 63		122,328 28	
Section 75, Roxbury,	26,846 51		36,202 78	
Section 76, Roxbury, cast-iron force main,	901 17		3,582 12	
Section 77, Roxbury, Ward Street pumping station,	6,841 24		10,973 79	
Section 78, Roxbury, connecting sewer,	287 53		1,240 90	
Real estate,	175,794 13		254,778 45*	
Apportionment Commission,	-		2,000 00	
Administration,	9,345 56		25,715 66	
Total,		1,371,981 64		1,763,892 58
Total, South Metropolitan System,		$1,384,589 32		$3,430,229 01
Total for construction, both systems,		$1,633,022 76		$8,995,936 82

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* Including $61,300.20 paid for Ward Street pumping station lot, and estimated amount of $14,000 for part of Adams estate purchase on account of sand for use in connection with construction of Section 48.

MAINTENANCE.	For Fifteen Months ending December 31, 1901.
North Metropolitan System,	$115,868 15
South Metropolitan System,	73,998 61
Total for maintenance,	$189,866 76

(5) Detailed Financial Statement.

The Board herewith presents, in accordance with the Metropolitan Sewerage Acts, an abstract of the expenditures and disbursements, receipts, assets and liabilities for the fifteen months ending December 31, 1901: —

(*a*) *Expenditures and Disbursements.*

GENERAL CHARACTER OF EXPENDITURES.	For Fifteen Months ending December 31, 1901.
North Metropolitan System — Construction.	
Commissioners,	$916 66
Secretary, engineer and auditor,	1,262 50
Clerical services,	1,141 68
Engineers, inspectors, rodmen, laborers and others,	26,393 34
Advertising,	220 02
Office supplies,	259 99
Postage, telephone and telegrams,	135 07
Books, maps, plans, blue prints and photography,	211 38
Engineering instruments and repairs of same,	45 79
Engineering supplies,	325 74
Carriage hire and travelling expenses,	634 68
Rent of office, Pemberton Building,	312 50
Rent of office, Melrose,	160 00
Teaming and express,	131 64
Tools and repairs of same,	301 66
Brick, cement, lumber and other field supplies,	9,240 36
Contracts: —	
Original work: —	
James Heath & Son, Sect. 35,	75 75
Wakefield branch: —	
John Booth Co., Sect. 50,	86 00
Chelsea and Everett outlets: —	
H. A. Hanscom & Co., Sect. 56,	31,747 71
H. A. Hanscom & Co., Sect. 57,	21,827 79
Wakefield branch extension: —	
Bruno, Salomone & Petitti, Sect. 58,	49,110 33
Chas. G. Belden & Co., Sect. 59,	47,719 76
Old Colony Construction Co., Sect. 60 (part),	10,841 01
Metropolitan Contracting Co., Sect. 60 (part),	35,571 58
Pumps and alterations, pumping plants,	7,860 00
Land takings, purchase and recording,	1,480 50
Experts and appraisers,	63 75
Legal services,	356 25
	$248,433 44
Neponset River Valley Sewer.	
Engineers, inspectors, rodmen, laborers and others,	$1,971 82
Advertising,	47 18
Office supplies,	13 79
Postage, telephone and telegrams,	31 90
Books, maps, plans, blue prints and photography,	23 58
Engineering instruments and repairs of same,	9 00
Amount carried forward,	$2,097 27

GENERAL CHARACTER OF EXPENDITURES.	For Fifteen Months ending December 31, 1901.
Amount brought forward,	$2,097 27
Neponset River Valley Sewer — Con.	
Engineering supplies,	105 55
Carriage hire and travelling expenses,	77 00
Teaming and express,	1 15
Brick, cement, lumber and other field supplies,	184 82
Contracts: —	
Brookline branch: —	
Thos. J. Kelley, Sect. 30,	6,942 59
Land takings, purchase and recording,	1,930 80
Experts and appraisers,	225 00
Legal services,	43 50
Claims on contracts,	1,000 00
	$12,607 68
High-level Sewer — Construction.	
Commissioners,	$4,750 00
Secretary, engineer and auditor,	5,879 15
Clerical services,	2,239 53
Engineers, inspectors, rodmen, laborers and others,	95,733 28
Advertising,	1,008 82
Office supplies,	2,382 42
Postage, telephone and telegrams,	536 45
Books, maps, plans, blue prints and photography,	921 37
Engineering instruments and repairs of same,	582 84
Engineering supplies,	2,323 11
Carriage hire and travelling expenses,	3,211 96
Repairs, fittings and supplies, main office,	118 77
Rent of office, Pemberton Building,	3,281 25
Rent of sub-offices,	672 75
Water rates and connections,	9,220 50
Clearing wood lot, Quincy,	888 77
Rent of office, Ashburton Place,	300 00
Rent of wharf, Quincy,	675 00
Boats and boat hire,	25 00
Teaming and express,	451 28
Tools and repairs of same,	21 84
Brick, cement, lumber and other field supplies,	10,125 32
Contracts: —	
Chas. G. Belden & Co., Sect. 47,	3,804 90
Chas. G. Belden & Co., Sect. 49,	50,423 48
Chas. G. Belden & Co., Sects. 48, 49, embankments,	19,188 46
Chas. G. Belden & Co., Sect. 50,	6,209 57
Thomas F. Moore, Sect. 51,	54,934 63
National Contracting Co., Sect. 52,	8,164 75
National Contracting Co., Sect. 53,	3,928 43
National Contracting Co., Sect. 54,	3,178 67
H. P. Nawn, Sect. 55,	93,075 17
National Contracting Co., Sect. 56,	76,733 30
J. W. Bustin & Co., Sect. 57,	3,468 17
Latta & Terry Co., Sect. 58,	711 87
H. P. Nawn, Sect. 59,	4,486 89
E. W. Everson & Co., Sect. 62,	100,386 83
National Contracting Co., Sect. 63,	71,793 78
Amount carried forward,	$645,838 31

GENERAL CHARACTER OF EXPENDITURES.	For Fifteen Months ending December 31, 1901.
Amount brought forward,	$645,838 31
High-level Sewer — Construction — Con.	
Contracts — *Con.*	
Beckwith & Quackenbush, Sect. 65,	21,025 75
Ed. W. & John J. Everson, Sect. 66,	85,951 71
Beckwith & Quackenbush, Sect. 68,	21,384 26
Beckwith & Quackenbush, Sect. 69,	38,494 89
Charles Linehan, Sect. 70,	55,400 77
Charles F. Taylor & Co., Sect. 71,	59,987 71
Jones & Meehan, Sect. 72,	101,063 22
National Contracting Co., Sect. 73,	30,811 12
H. P. Nawn, Sect 74,	111,947 10
Shailer & Schniglau Co., Sect. 75 (part),	22,710 89
Land takings, purchase and recording,	170,713 94
Experts and appraisers,	2,621 77
Legal services,	2,380 20
Claims and allowances on contracts,	1,650 00
Total,	$1,371,981 64
North Metropolitan System — Maintenance.	
Administration: —	
Commissioners, secretary, auditor and assistants,	$1,697 19
Postage, printing, stationery and office supplies,	248 05
Miscellaneous expenses,	401 62
General superintendence: —	
Engineer and assistants,	6,841 56
Postage, printing, stationery and office supplies,	435 49
Rent, telephone, heating, lighting and care of offices,	370 35
Miscellaneous expenses,	204 24
Deer Island pumping station: —	
Labor,	12,520 07
Coal,	7,111 47
Oil and waste,	488 60
Water,	1,639 20
Packing,	88 35
Repairs and renewals,	949 84
Telephones and office supplies,	320 11
Miscellaneous supplies and expenses,	1,575 96
East Boston pumping station: —	
Labor,	12,363 44
Coal,	9,809 70
Oil and waste,	280 92
Water,	1,083 60
Packing,	72 12
Repairs and renewals,	1,769 56
Telephones and office supplies,	219 05
Miscellaneous supplies and expenses,	1,018 47
Charlestown pumping station: —	
Labor,	11,256 67
Coal,	4,237 20
Oil and waste,	322 98
Water,	484 80
Packing,	139 72
Amount carried forward,	$77,950 33

GENERAL CHARACTER OF EXPENDITURES.	For Fifteen Months ending December 31, 1901.
Amount brought forward,	$77,950 33
North Metropolitan System — Maintenance — Con.	
Charlestown pumping station — *Con.*	
Repairs and renewals,	838 35
Telephones and office supplies,	239 99
Miscellaneous supplies and expenses,	921 22
Alewife Brook pumping station: —	
Labor,	3,746 79
Coal,	2,014 46
Oil and waste,	130 09
Water,	384 16
Packing,	21 05
Repairs and renewals,	169 21
Telephones and office supplies,	215 92
Miscellaneous supplies and expenses,	621 25
Sewer lines, labor,	21,824 08
Supplies and expenses,	4,791 25
Apportionment Commission,	2,000 00
Total,	$115,868 15
South Metropolitan System — Maintenance.	
Administration: —	
Commissioners, secretary, auditor and assistants,	$333 33
Postage, printing, stationery and office supplies,	120 98
General superintendence: —	
Engineer and assistants,	1,288 34
Postage, printing, stationery and office supplies,	13 88
Charles River valley sewer: —	
Sewer lines, labor,	3,368 50
Supplies and expenses,	116 59
City of Boston, for pumping and interest,	44,345 39
Neponset River valley sewer: —	
Sewer lines, labor,	2,151 28
Supplies and expenses,	144 75
City of Boston, for pumping and interest,	17,290 00
Quincy pumping station:* —	
Labor,	2,392 28
Coal,	1,288 42
Oil and waste,	19 91
Water,	10 00
Packing,	15 98
Repairs and renewals,	448 34
Telephones and office supplies,	44 42
Miscellaneous supplies and expenses,	606 22
Total,	$73,998 61

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* From April 1, 1901.

(*b*) *Receipts.*

The receipts from the sales of property, from rents and from other sources have been credited as follows: —

	For Fifteen Months ending December 31, 1901.	From Beginning of Work to December 31, 1901.
North Metropolitan System, — construction,	$6,765 55	$16,057 53
Neponset River valley sewer, — construction,	-	109 50
High-level sewer, — construction,	575 00	575 00
North Metropolitan System, — maintenance,	325 02	325 02
South Metropolitan System, — maintenance,	10 00	10 00
Metropolitan Sewerage Loans Sinking Fund,	318 85	318 85
Totals,	$7,994 42	$17,395 90

(c) *Assets.*

The following is an abstract of the assets, the more important items being given: —

Office furniture, fixtures and supplies: —

2 book cases; 8 plan cases; 37 miscellaneous cases and cabinets; 137 chairs; 17 desks; 2 letter-copying presses; railroad tickets (value), $357.26; 25 reference books; 52 stools; 35 coal stoves; 25 tables (office); 26 tables (drafting); 1 telephone line (private); 1 typewriter; stamped envelopes (value), $18.50.

Engineering and scientific instruments and supplies: —

6 drawing boards; 1 calculating instrument; 1 cement-testing machine; 1 current meter; 9 engineers' levels; 2 pantographs; 1 photographic outfit; 6 planimeters; 94 levelling, measuring and sight rods; 84 pairs rubber boots; 84 scales; 2 section liners; 12 straight-edges; 60 tapes; 12 transits.

Horses, vehicles, field machinery, etc.: —

1 horse; 1 cart; 1 sled; 1 wagon; 1 road roller; 2 harnesses; 8 bush hooks, bill hooks, scythes, etc.; 2 hand carts; 3 iron hand rollers; 5 lawn mowers.

Machinery, tools and other appliances and supplies: —

7 adzes; 4 anchors; 7 anvils; 27 axes and hatchets; 32 barrows; 23 bars, crow and others; 1 blacksmithing outfit; 1 blasting battery; 52 blocks, all kinds; 4 blowers; 10 row boats; 1 boat, naphtha launch; 21 boilers; 102 chisels; 4 carts and cars; 9 chain hoists; 5 derricks; 14 drilling machines; 5 dynamos; 16 engines; 10 gages; 7 grindstones; 18 hoes, all kinds; 4 forks,; 56 hammers; 7 hoisting buckets; 1,695 feet hose, all sizes; 3 indicators; 2 injectors and inspirators; 11 jacks; 1,200 feet ladders; 3 lathes; 10 M feet B. M. lumber; 4 mattocks; 15 mauls; 2 meters, pressure, etc.; 10 oil cabinets and tanks; 13 pipe cutters; 18 die plates, stocks, etc.; 72 picks; 3 plumber's furnaces; 14 pumping engines; 25 steam pumps; 1 centrifugal pump; 6 diaphragm pumps; 8 miscellaneous pumps; 15 rakes; 1 rock drill; 34 saws; 13 scales, yard, platform, etc.; 104 shovels, scoops, spades, etc.; 13 steam siphons; 43 temporary buildings and structures; 24 tongs; 24 tool and coal boxes, etc.,; 10 trench and other braces; 1 truck; 14 vises; 2 winches; 274 wrenches; 2,427 feet wrought-iron pipe, all sizes.

Real estate connected with works not completed: —

Land for the Ward Street pumping station, Roxbury; for the outfall sewer at Nut Island, Boston harbor; and for other portions of the high-level sewer.

Completed works, including real estate connected therewith: —

Pumping stations at Deer Island, East Boston, Charlestown, Somerville and Quincy; 82.47 miles of completed sewer; stock yards and buildings at Deer Island, East Boston and at Hyde Park, and vacant lots in Winthrop and Chelsea.

(*d*) *Liabilities.*

There are liabilities as follows: —

Unpaid bills, ...	$18,400 00*
Due on monthly pay rolls, ...	1,886 00
	$20,286 00

Amounts on Monthly Estimates, not due until Completion of Contracts or until Claims are settled.

NAME.	Work.	Amount.
North Metropolitan Construction: —		
The George F. Blake Manufacturing Co.	Original work, Alewife Brook pumping station.	$1,875 00
John Sheehan, . . .	Original work, Sect. 20, . . .	450 00
John Sheehan, . . .	Original work, Sect 37, . . .	4,458 18
Jones & Meehan, . . .	Original work, Sect. 44, . . .	32 00
H. A. Hanscom & Co., .	Chelsea and Everett outlets, Sect. 56,	1,670 93
H. A. Hanscom & Co., .	Chelsea and Everett outlets, Sect. 57,	1,148 83
Bruno, Salomone & Petitti,	Wakefield branch extension, Sect. 58,	2,584 77
Chas. G. Belden & Co., .	Wakefield branch extension, Sect. 59,	2,511 57
Old Colony Const. Co., .	Wakefield branch extension, Sect. 60,	1,894 17†
Metropolitan Contg. Co., .	Wakefield branch extension, Sect. 60,	6,277 33
Neponset Valley System: —		
E. W. Everson & Co., . .	Original work, Sect. 25, . . .	50 00
Thos. J. Kelley, . .	Brookline branch, Sect. 30, . .	1,225 16
High-level sewer: —		
Chas. G. Belden & Co., .	Sect. 47, ...	671 45
Chas. G. Belden & Co., .	Sects. 48, 49, embankments, . .	3,386 21
Chas. G. Belden & Co., .	Sect. 49, ...	8,898 25
Chas. G. Belden & Co., .	Sect. 50, ...	1,095 81
Thomas F. Moore, . .	Sect. 51, ...	9,879 48
National Contracting Co., .	Sect. 52, ...	1,661 39
National Contracting Co., .	Sect. 53, ...	747 74
National Contracting Co., .	Sect. 54, ...	679 62
H. P. Nawn, ...	Sect. 55, ...	8,529 94
National Contracting Co., .	Sect. 56, ...	13,663 60
J. W. Bustin & Co., . .	Sect. 57, ...	612 03
Latta & Terry Co., . .	Sect. 58, ...	125 63
H. P. Nawn, ...	Sect. 59, ...	884 66
E. W. Everson & Co., .	Sect. 62, ...	6,034 77
National Contracting Co., .	Sect. 63, ...	12,928 52
E. W. & John J. Everson, .	Sect. 66, ...	18,543 70
Charles Linehan, . .	Sect. 70, ...	13,480 48
Charles F. Taylor & Co., .	Sect. 71, ...	4,206 98
Jones & Meehan, . .	Sect. 72, ...	6,121 57
National Contracting Co.,	Sect. 73, ...	5,481 82
H. P. Nawn, ...	Sect. 74, ...	4,535 33
E. W. Everson & Co., .	Sect. 75, ...	184 50
		$146,531 42

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* Miscellaneous current bills of 1901 and those coming in from time to time after January 1, 1902, have since been paid.

† Labor and other claims paid by the Board exceed this amount.

Amounts have been agreed upon in the following cases, but the deeds have not yet passed: —

Heirs of Austin White, $100; William Bogle, $1,250; George H. Hardwick, $75; Jennie M. Kimball, $500.

On the claims of the following it is impossible to state the amounts due for land and other damages, as suits are now pending in the courts for the determination of the same: —

Joseph Stone *et al.*, Amos Stone *et al.*, city of Boston, Henry W. Hunt *et al.*, Peter P. Veale, Margaret Noon, Evangelical Lutheran Church, William Finneran, Harvard College, Charles L. Flint, Jacob Schaffreen, Theodore H. Tyndale, John Sheehan, Mary E. Connolly, Mary Rohan.

VIII. ADMISSION OF OTHER MUNICIPALITIES INTO THE METROPOLITAN WATER DISTRICT.

In accordance with negotiations which were taking place at the end of the preceding year, Stoneham was admitted into the Metropolitan Water District on May 23, 1901. It was agreed between the Board and the town that water might be furnished to the town from a reservoir to be constructed by the Board on Bear Hill at an elevation of between 295 and 300 feet above the Boston city base, when full, and that water should be delivered into main pipes of the town at the junction of Main and Franklin streets. As the building of a reservoir on Bear Hill, the laying of a considerable length of main pipe in order to connect with the Stoneham water system, and the extra pumping, involved the expenditure of a considerable sum of money, the payment of $30,000 by the town was required. These works were so far completed that water was supplied to the town on October 21, 1901.

IX. ADDITIONAL LOANS AND CHANGES OF ASSESSMENTS FOR METROPOLITAN WATER WORKS.

Attention was called, in the report of the Metropolitan Water Board of last year, to the necessity of authorizing an additional water loan, in order to provide for expenditures which had not been contemplated by the original Metropolitan Water Act. A recommendation for such loan was made by the Governor in his message to the Legislature. The additional appropriation was principally required for the construction of the Weston Aqueduct, and for the amount adjudged to be due to the city of Boston on account of the taking of its works.

An act was accordingly passed, on June 5, 1901, authorizing a Metropolitan Water Loan to an amount not exceeding $13,000,000, in addition to the $27,000,000 previously authorized.

The attention of the Metropolitan Water District and of the Legislature had also been called to the provisions of the original Metropolitan Water Act, by which the annual assessments imposed upon the cities and towns in the District were insufficient for several years to meet the entire cost of maintenance, the interest on the loan and the requirements of the sinking fund. The assessments began in the year 1898, and, besides the amount of $42,500 added on account of the preliminary expenditures of the State Board of Health, the sum of $300,000 only was assessed for that year; and, although it was provided that an increase of $200,000 in the amount of the assessment should be made in each successive year, the annual assessments would be inadequate to meet the total of the annual requirements for several years, so that, to meet the successive deficiencies, the amount of the water loan ultimately necessary would have to be increased by about $4,000,000.

Chapter 489 of the Acts of the year 1901 was passed on June 13, and provided that the assessment for the current year, and of each year thereafter, should be sufficient to meet the annual requirements for maintenance, interest and the sinking fund. Although the passage of this act increased to a considerable extent the amount of the assessment for the year 1901 over that of the preceding year, this action will result in a smaller maximum assessment in the future, and wisely requires the payment of current expenditures by current assessments.

X. MEASURES TO PREVENT WASTE AND EXCESSIVE USE OF WATER.

The Board deems it to be its duty to the Metropolitan Water District again to call attention, not only to the large consumption of water, but also to the great increase in consumption occurring from year to year. The State Board of Health in its report of 1895 stated that the average daily consumption of water in the Metropolitan District for the preceding year was 79,046,000 gallons. In that report the State Board estimated that the daily consumption would, in the year 1895, reach 84,000,000 gallons, or 85 gallons per inhabitant, and that the daily consumption in the year 1900 would reach 103,000,000 gallons, or 90 gallons per inhabitant. It was estimated that a consumption of 100 gallons per inhabitant would be reached in the year 1920; and, in making its calculations as to future needs of the District, it was estimated that, with the consumption of 100 gallons per inhabitant, the sources of supply then recommended would be sufficient until the year 1920. The district for which the calculation was made embraced not simply the cities and towns now in the District, but all the cities and towns within the ten-mile limit.

In the year 1895 the daily consumption in the cities and towns now constituting the District amounted to 69,188,000 gallons, — a daily consumption per inhabitant of 92 gallons. In the year 1901 the daily consumption of water in the District had reached 104,178,000 gallons, — a daily consumption of 117 gallons per inhabitant.

A greater increase than was estimated called for the construction of the Weston Aqueduct two or three years prior to the time when its need had been anticipated. An increase in the next few years corresponding to that which has occurred since the beginning of the operations of the Board will compel resort to be had in a very few years to additional sources of supply, at a date ten or twelve years earlier than had been estimated under the calculations made by the State Board of Health in the year 1895.

It is not necessary to repeat that this increase in consumption causes a great increase in the annual expenditures for maintenance and operation, and that it hastens the time when great expenditures must be incurred for new sources of supply, new pumping facilities, new aqueducts, and new mains and other equipments.

The Board continues of the belief that the annual consumption of water in the District is greater than is necessary, and that there is considerable waste and misuse of water. It has during the year continued to urge many of the municipalities to adopt stricter regulations in the consumption of water and to make a more rigorous enforcement of rules.

The Board, acting under the authority granted to it under section 10 of the Metropolitan Water Act, which provides that the Board may take all proper measures to prevent the improper use or waste of water, adopted, on August 2, 1901, the following regulations in regard to the use of hand hose and lawn sprinklers, to be enforced throughout the District on and after January 1, 1902: —

> The use of water through hand hose on premises where the water supply is *not* metered shall be restricted to two hours in each day, such use to be had between the hours of 5 and 8 A.M. and 5 and 8 P.M.
>
> The hose must be used with a nozzle not exceeding three-sixteenths of an inch in diameter, and while so used must be held in the hand of a person on the premises of the water taker.
>
> On premises where the water supply *is* metered, the above restrictions do not apply, and a lawn sprinkler may be attached to the hose.

The Board also gave notice that the charge for hand hose used in accordance with these regulations would not be less than $4 per annum.

The question of the prevention of the excessive use and waste of water was made the subject of conferences between the Board and the various water boards and other officials in the District in the early part of the year. The subject, as more especially discussed, was the introduction of water meters to individual water takers. There was considerable difference in opinion as to whether the time had come for either compelling or for urging or directly encouraging the use of meters by individual takers; but there seemed to be a general opinion expressed that it would be wise that the water supplied to the various cities and towns should be measured, and that the amount of the consumption of water should become an element in fixing, so far as practicable, the annual assessment.

The Board accordingly caused investigations to be made as to the feasibility of determining, by meters or otherwise, the amount of water furnished to each city and town in the District; and, although it was ascertained that the cost of such determinations would be considerable, it seemed that such cost would be justified, even if not called for on other grounds, if the different cities and towns could thus be given a pecuniary motive for enforcing proper regulations against waste and excessive use of water.

Inasmuch as the Metropolitan Water Act provided that the annual assessments upon the cities and towns, other than the city of Boston, should be apportioned one-third in proportion to their respective valuations and the remaining two-thirds in proportion to their respective populations, the Board believed that to substitute for the element of population the quantity of water used, so that the assessment should be based one-third in proportion to the valuations and two-thirds in proportion to the quantities of water respectively used, would be a step in the direction of checking waste and excessive use, and would operate for the benefit of the entire District.

The Board trusts that the results of the investigations which it has begun upon this subject will enable it to make future recommendations tending further to check unnecessary consumption.

The inadequacy of the present aqueducts to furnish the quantities of water required under the larger consumption in periods of excessive drafts upon the works may require at times a special economy in use until the new Weston Aqueduct is able to aid the resources of the present aqueducts.

XI. ELECTROLYSIS AFFECTING IRON PIPES.

The Board has been having extended investigations made as to the effects upon iron pipes of the underground electric currents. For some years injurious effects have been observed from the action of electricity upon water and other pipes. The examinations which have been made are convincing that the electric currents from the street railway systems have already caused serious damage to the pipe lines. This injury has thus far, in general, been found in pipes in the vicinity of the power stations of the street railway systems, but it is probable that the injuries exist in other places, and especially that there has been destructive action taking place at the joints of the pipes.

The injury which has already been caused is of large amount, and, if the present conditions continue, they will result in a large destruction of pipes within a very few years. The cost, however, of replacing these pipes is but a minimum of the damage which may be occasioned. By the sudden breakage of pipes, large damage may be caused to neighboring property in thickly settled districts, and serious consequences may ensue where large portions of the District are dependent upon a single line of pipe.

It would seem that this electrical action, resulting from the operation of electric railways, may be prevented by the use of a double trolley system, in which return currents shall be insulated from the rails and from the earth.

The damages which are occasioned are by no means confined to the pipes belonging to the Metropolitan Water and Sewerage Board.

The attention of the railway companies has been from time to time called to the matter, but it would seem that efficient and radical measures must soon be called for to remedy these difficulties.

XII. RECOMMENDATIONS FOR LEGISLATION.

In a preliminary report made to the Legislature (House Document, No. 26) the following recommendations for legislation for the current year, under both the water and sewerage acts, were made: —

> Application has been made to the Board in one or two instances that a supply of water from the Metropolitan System be furnished to sections of a town that is embraced within the ten-mile limit prescribed by the Metropolitan Water Act (chapter 488 of the Acts of the year 1895), which are not reached by the water pipe system that supplies the larger portion of the town. If a town is within the ten-mile limit, the act provides that the Board shall admit the town, on its application, into the District, and furnish it water; or shall furnish water to any water company owning the water pipe system in the town, on such company assuming the assessments of the town, if any, and such payment of money as the Board may determine. The act does not contemplate the existence of two or more water companies or systems supplying water to different sections of a town. Were such town without the ten-mile limit, the Board might under the act furnish any such section with water, upon such payment of money as the Board might determine. Recommendation is made that the act be so amended that the Board may furnish water to a water company in a town within the ten-mile limit, but not admitted into the District, which owns the water pipe system of a section of a town, on the water company paying such sum of money as the Board may determine, such sum to exceed in any case the proper proportion of the entire assessment which would be imposed upon the town were it a part of the Metropolitan Water District.
>
> By the various acts under which the Metropolitan Sewerage Commissioners were authorized to construct the different systems of sewerage, different points of time were fixed at which the taking of lands for sewer purposes should take effect. It would seem, though not without some doubt, that, at the time of the consolidation of the commission with the Metropolitan Water Board, the statutes provided that the takings of lands for the sewerage works should take effect on the passage by the Board of the order for the taking; on the other hand, the Metropolitan Water Act provided that all takings of lands for water works should take effect upon the recording of the instrument of taking in the registry of deeds. It is manifestly desirable that no doubt should exist as to the time when the takings become effective, and that the same rule should apply to all takings of land by the consolidated Board; and the Board recommends the passage of an act to this effect.

XIII. FUTURE WORK.

Upon both the water and sewerage works a large amount of construction work will be required during the coming year.

The stripping and removal of soil from the Wachusett Reservoir will be continued as rapidly as during the last year; the work upon the Wachusett Dam and Weston Aqueduct, which has been well begun, will be prosecuted with larger forces; considerable lines of main pipe will be laid in order to convey water from the Weston Aqueduct into the District, and to complete a second connection between Chestnut Hill Reservoir and Spot Pond; the excavation and improvement of the Pegan Brook Meadow in Lake Cochituate will require vigorous efforts for its completion within the time limited; and there will be need of a large amount of construction work in the relocation of the Central Massachusetts Railroad, an undertaking which will have to be well advanced toward completion during the year.

The construction of the high-level sewer in the South Metropolitan System, which has likewise been well advanced, will call for more sewerage work than in any previous year, and involve the difficult operations of laying submarine pipes for the outlet off Nut Island; a new pumping station at Ward Street in Roxbury must be begun, and engines and other equipment for its operation must be supplied.

The report of the Chief Engineer, relating to the Metropolitan Water Works, and the report of the Engineer of the Metropolitan Sewerage Works, are herewith submitted.

Respectfully submitted,

HENRY H. SPRAGUE.
HENRY P. WALCOTT.
JAMES A. BAILEY, Jr.

BOSTON, January 1, 1902.

REPORT OF THE CHIEF ENGINEER.

To the Metropolitan Water and Sewerage Board.

Gentlemen: — The following is a report of the operations of the Engineering Department of the Metropolitan Water Works for the year ending December 31, 1901.

Organization.

The general organization of the Engineering Department remains the same as last year. The list of engineers reporting directly to the Chief Engineer is as follows: —

Dexter Brackett,	*Engineer, Distribution Department.*
Desmond FitzGerald,	*Engineer, Sudbury Department.*
Thomas F. Richardson,	*Engineer, Dam and Aqueduct Department.*
Hiram A. Miller,	*Engineer, Reservoir Department.*
Horace Ropes,	*Engineer, Weston Aqueduct Department.*
Alfred D. Flinn,	*Principal Office Assistant.*
John N. Ferguson,	*Office Assistant.*

Joseph P. Davis, A. Fteley and Hiram F. Mills have continued as consulting engineers.

John W. Lynch has continued in direct charge of the pumping stations at Chestnut Hill, and in general charge of the mechanical work at all other pumping stations of the Distribution Department.

Charles E. Haberstroh has continued as assistant superintendent in the Sudbury Department, in immediate charge of the storage reservoirs and other works on the Sudbury and Cochituate watersheds and of the Sudbury and Cochituate aqueducts.

George E. Wilde has continued as assistant superintendent in the Distribution Department, in immediate charge of the maintenance and operation of the pipe lines and other works within the Metropolitan District, with the exception of the pumping stations, and is also engaged at times upon the work of construction.

At the beginning of the year the engineering force, including both those engaged upon the construction and maintenance of the works, numbered 159, and at the end of the year 158; and during the year fluctuated from a minimum of 147, in the spring, to a maximum of 190, in August.

In addition to the engineering force, which included the engineers engaged upon the inspection of the work, other inspectors have been employed upon masonry, earthwork and pipe laying. The maximum number so employed at any one time during the year was 12.

Gangs of men under the immediate direction of foremen and under the general direction of the engineers have been employed from time to time to do minor work, the more important items of which are improvements at Lake Cochituate, preliminary work at the Weston Reservoir, repairs at the Waban Hill Reservoir in Newton, and pipe laying in the Metropolitan Water District. There has also been a maintenance force, averaging 185, employed at the pumping stations and in connection with the maintenance of reservoirs, aqueducts, pipe lines, swamp ditches and other works.

FORCE EMPLOYED ON WORKS.

The force employed upon the works in 1901 was considerably larger than the force employed in 1900, owing to the increased amount of contract work.

The largest force employed upon the works at any one time during the year was in the latter part of August, as follows: —

	Men.		Horses.	
Contractors' force: —				
Reservoir Department,	1,296		163	
Dam and Aqueduct Department,	312		16	
Weston Aqueduct Department,	819		113	
Distribution Department,	241		30	
	——	2,668	——	322
Day-labor force, construction,		40		2
Engineering force, including engineer inspectors and those engaged upon maintenance,		188		-
Inspectors not engineers,		10		-
Maintenance force, not including civil engineers,		203		-
		3,109		324

ARRANGEMENT OF REPORT.

In continuing this report, it is the purpose to separate the work charged to the construction account from that charged to the maintenance account; but, as the work of construction and maintenance is supervised by the same principal engineers, and in very many cases the assistants are engaged upon both classes of work, it is not feasible to make a complete separation.

CONSTRUCTION.

CONTRACTS.

A detailed statement of the contracts made and pending during the year is given in Appendix No. 1. The following statement gives a summary of all the formal contracts charged to construction from the beginning of the work to the end of 1901: —

PORTION OF WORK.	Number of Contracts.	Approximate Amount.
Wachusett Reservoir, ...	24	$2,230,843 26
Wachusett Aqueduct and Clinton sewerage, . . .	20	1,516,259 67
Wachusett Dam, ...	3	1,629,406 56
Sudbury Reservoir, contracts assumed from the city of Boston (uncompleted portions), ...	11	583,220 54
Sudbury Department, reservoir, filter-beds, pipe lines and improvement of Lake Cochituate, contracts made by Metropolitan Water and Sewerage Board, . .	21	909,850 72
Weston Aqueduct and Reservoir, ...	14	1,815,129 50
Distribution Department, including pipes, valves and special castings purchased for other departments, .	138	4,117,447 75
Totals, ...	231	$12,802,158 00

Number of contracts made in 1901, ...	25
Number of contracts completed in 1901, ...	11
Total number of contracts made to December 31, 1901, ...	231

Amount of contracts made and assumed in 1896, including only the uncompleted portions of contracts assumed from the city of Boston, ...	$3,893,934 31
Amount of contracts made in 1897, ...	1,271,960 64
Amount of contracts made in 1898, ...	743,748 75
Amount of contracts made in 1899 (approximate), ...	2,398,411 47
Amount of contracts made in 1900 (approximate), ...	1,751,176 10
Amount of contracts made in 1901 (approximate), ...	2,742,926 73
	$12,802,158 00

Amount of contracts completed to December 31, 1900, ...	$6,862,991 67
Amount of contracts completed in 1901, ...	791,806 72
	$7,654,798 39
Amount of 26 contracts uncompleted December 31, 1901 (approximate), ...	5,659,359 61
	$13,314,158 00
Deduct for work done on 11 Sudbury Reservoir contracts by city of Boston, ...	512,000 00
	$12,802,158 00
Value of work done by contract to December 31, 1896, ...	$2,061,910 38
Value of work done by contract from January 1, 1897, to December 31, 1897, ...	2,647,063 53
Value of work done by contract from January 1, 1898, to December 31, 1898, ...	703,141 71
Value of work done by contract from January 1, 1899, to December 31, 1899, ...	1,206,791 72
Value of work done by contract from January 1, 1900, to December 31, 1900, ...	927,034 80
Value of work done by contract from January 1, 1901, to December 31, 1901, ...	1,067,540 70
	$8,613,482 84
Value of work remaining to be done on 26 uncompleted contracts December 31, 1901 (approximate), ...	4,188,675 16
	$12,802,158 00

In the case of all contracts completed up to the present time final settlements have been made without any legal controversy, and there have been no strikes of employés which went beyond an incipient stage or lasted more than two or three days.

RESERVOIR DEPARTMENT.

Hiram A. Miller, *Department Engineer.*

The organization of the engineering force has been substantially the same as during the previous year. Alexander E. Kastl, division engineer, in charge of the work at the North Dike, was on June 10, 1901, transferred to the Dam and Aqueduct Department, to take charge of surveys for the relocation of the Central Massachusetts Railroad; and Harry J. Morrison, assistant engineer, at the head of the engineering force at West Boylston, was promoted to the vacancy caused by this transfer. Charles E. Wells, division engineer, has continued in charge of the inspection of the removal of soil from the Wachusett Reservoir and the supervision of the contractors on that work. Charles A. Bowman, division engineer, has continued in charge of the force reports, measurements, estimates and miscellaneous engineering work connected with the removal of soil. Moses J. Look, assistant engineer, had charge of preliminary investigations, road construction and miscellaneous work, and on the promotion of Mr. Morrison was advanced to the place left vacant by him.

H. B. Wason, an engineer engaged on the inspection of the removal of soil from the reservoir, was stricken with typhoid fever on October 19, and died at the Clinton Hospital on October 28. This was the second year of his connection with the department. He showed unusual faithfulness and ability in the performance of the work entrusted to him.

The total engineering force in this department has varied from 47 to 68.

The main office of this department is in Clinton. Three branch offices, one near the North Dike, in Clinton, one at Sawyer's Mills and the other at West Boylston, have been continued throughout the year; and another one was established in the easterly part of West Boylston, in May, for one of the engineering parties engaged upon the removal of soil from the Wachusett Reservoir.

NORTH DIKE.

Work upon the North Dike has been in progress during the year under the contractors Nawn & Brock, Long & Little and the Newell & Snowling Construction Company.

The work done by each will be described more fully under the head of contracts. The total amount of work done during the year, with the total amount to date, is given in the following table: —

	To December 31, 1900.	For the Year 1901.	Total to December 31, 1901.
Soil and earth excavated from main cut-off trench (cubic yards), ...	499,856	-	499,856
Soil and earth excavated from secondary cut-off trench (cubic yards), ...	42,033	-	42,033
Sheet piling driven (linear feet), ...	5,245	-	5,245
Surface of rock uncovered and treated at bottom of main cut-off trench (square feet), .	77,250	-	77,250
Soil from reservoir deposited in cut-off trenches and in the dike (cubic yards), ...	2,110,354	1,308,485	3,418,839
Earth and gravel taken from borrow pits and deposited in the dike (cubic yards), . .	42,725	55,630	98,355
Earth excavation for the construction of a small dike in Coachlace Pond (cubic yards),	19,172	-	19,172
Drain pipe laid at toe of the westerly portion of the dike (linear feet), ...	7,083	-	7,083

The present condition of the dike, relative to its completion, is as follows: The excavation of the main and secondary cut-off trenches, the filling with soil of the secondary cut-off trench and the driving of the sheet piling, had been completed at the beginning of 1901. The filling of the main cut-off trench with soil has continued during the year, and is substantially completed. Of the soil filling, which constitutes the principal part of the dike, 3,418,839 cubic yards have been deposited, which is 64 per cent. of the total amount required, as at present estimated.

Work has continued on the embankment of earth and gravel on the water side of the dike. The total amount deposited to the end of the year was 98,355 cubic yards.

The westerly portion of the dike, for a distance of 1,200 feet at its easterly end, was completed ready for the slope paving in October, and accepted from the contractor under the terms of the contract.

The consolidation of the soil placed in the dike is accomplished by saturating it with water. This work, which is done by a day-labor force, was in progress at the beginning of the year, and was continued until March 16, while the contract work was suspended. On November 14 a pump was located on the northerly shore of Sandy Pond, and pipes were laid from the pump to the dike for the purpose of continuing the saturation during the winter. The pump was started on December 11 and was kept in operation until the end of the year, most of the time day and night. Other day-labor work consisted of sowing grass seed on a finished portion of the dike, removing the buildings at the dike, cutting and burning weeds and digging test pits.

The maximum day-labor force employed at the dike was 27 men and 5 horses, for the week ending December 28, 1901.

Relocation and Construction of Roads.

Considerable progress has been made on surveys and studies for the relocation of roads at the upper end of the reservoir, to take the place of those to be discontinued, but no contracts for road construction have been made during the year.

The determination of the location of a new road across the reservoir in West Boylston, connecting Worcester Street on the southerly side with Sterling and Lancaster streets on the northerly side, was made by the Board and was agreed to by the county commissioners of Worcester County on November 19, 1901.

The paving of the water channels along Boylston Street in Clinton and Boylston, along the Shrewsbury Road in Boylston and West Boylston, and along the new road from Clinton to West Boylston, in Sterling, where this paving is within or near the reservoir, has been maintained.

The soil used for dressing the slope of the embankment of Boylston Street, opposite Oak Street, slid from a portion of the embankment during the heavy rain of April 7. The embankment was drained by digging trenches in the clayey material and filling them with small stones before the soil was replaced.

The highway bridge in West Boylston, over the canal leading from the river to the Clarendon Mills, was repaired.

Some clearing and other preliminary work was done preparatory to the construction of the highway on the northerly side of the reservoir across the dike.

Several old roads in Boylston and West Boylston were discontinued as highways by the Board on June 1, 1901, so that they are no longer maintained by the towns in which they are situated. It is, however, necessary to keep them in condition for travel while the work is in progress, and many repairs have been necessary; some of these have been made by the contractors and some by the day-labor forces of the Board.

The maximum day-labor force employed in connection with the work upon the roads was 30 men and 10 horses, for the week ending May 25, 1901.

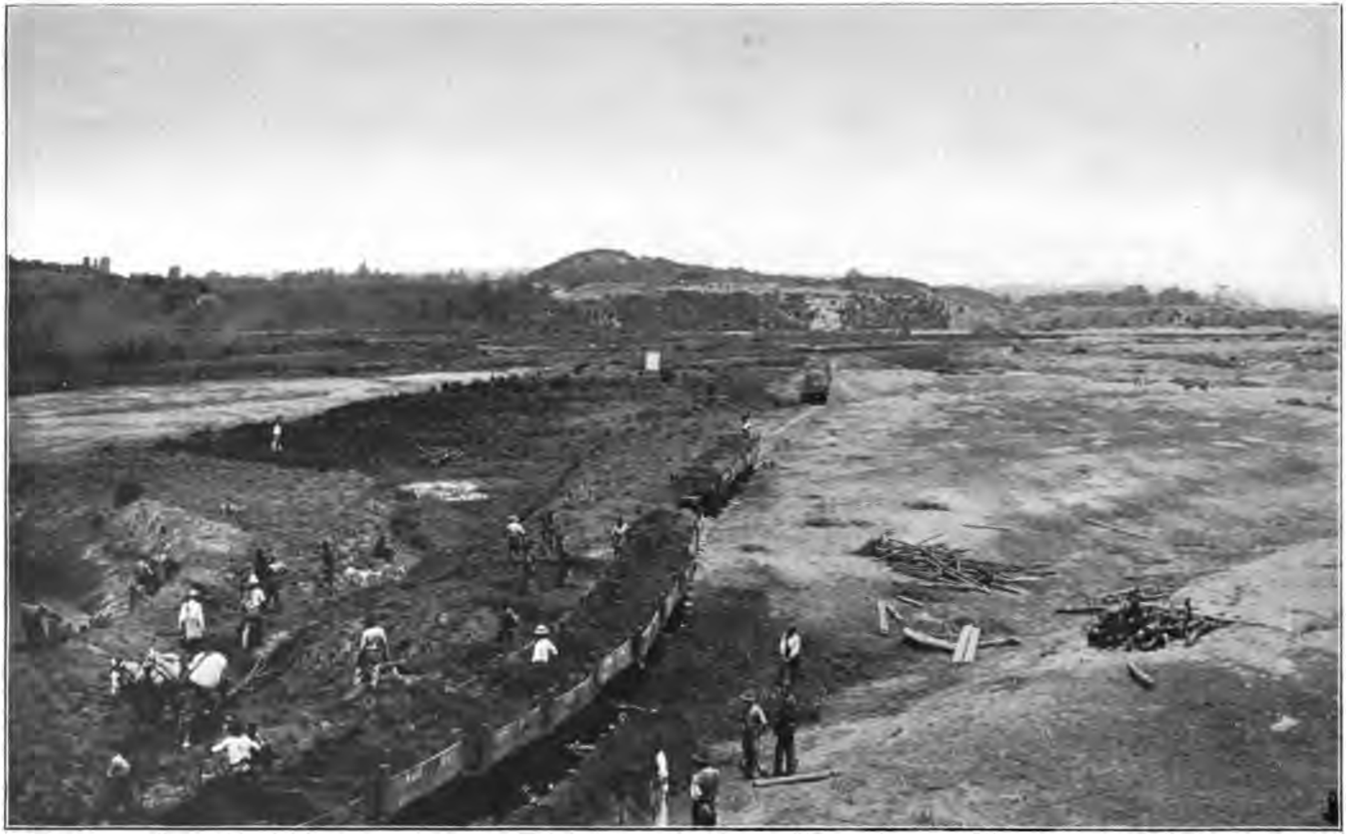
Considerable work has been done by the engineers in making plans for the location and construction of new roads toward the upper end of the reservoir and for the discontinuance of roads in other portions of the reservoir.

Removal of Soil.

Work upon the removal of soil from the reservoir has been in progress by the contractors already mentioned under the heading "North Dike."

A large contract for removing the soil required for completing the westerly portion of the dike has been made. This will be described more fully under the head of contracts.

The total amount of soil removed and to be removed from the Wachusett Reservoir is at present estimated to be about 6,900,000



WACHUSETT RESERVOIR — STRIPPING AND REMOVAL OF SOIL IN BOYLSTON.

cubic yards, from approximately 4,200 acres. Of this, the total amount removed from the reservoir in previous years was 2,278,723 cubic yards, from 1,358 acres; in 1901, 1,309,925 cubic yards were removed, from 758 acres; making a total from the beginning of work to the end of 1901 of 3,588,648 cubic yards, or 52 per cent. of the total, as at present estimated, removed from 2,116 acres. Of the soil remaining, the removal of more than one-half is provided for under existing contracts.

Of the soil removed to the end of the year 1901, 167,389 cubic yards were used for road embankments, 2,420 cubic yards for shallow-flowage areas, and 3,418,839 cubic yards have been used in the dike. There have been 40,885 cubic yards of earth used to cover deep muck to the depth of about 1 foot; this amount, added to the 9,008 cubic yards used for the same purpose during the previous year, gives a total of 49,893 cubic yards.

During the year, with the exception of a small portion which has been loaded into dump carts and hauled directly to the dike, the soil excavated has been loaded into cars, or first loaded into carts and then dumped into cars at the dumping platforms. A very large part of the soil loaded into cars has been hauled directly to the dike, by locomotives, over the main line of double track which passes near the South Clinton station. A considerable portion, however, has been hauled by locomotives to the foot of two inclines, and there hauled by stationary engines to the top of the bluff, to be again hauled by locomotives at a higher level to the dike. One of these inclines was situated on the northerly side of the river, about midway between the South Clinton station and Sawyer's Mills; the other, near the old West Boylston Road, a short distance west of Sawyer's Mills. During the early part of the year some soil was transported over a railway extending from the river, at the "Ox-bow," to the dike, east of Coachlace Pond.

The plant employed in this work toward the end of the season, exclusive of horses and carts, included 27.3 miles of 3-foot-gage track, 25 8 to 16 ton locomotives, 720 cars, 1¾ to 3½ cubic yards' capacity, 1 70-horse-power hoisting engine and 1 50-horse-power hoisting engine.

A day-labor force under the direction of the engineering force performed the following work: The water in Oakdale mill-pond was lowered, the gate repaired, and drainage ditches were dug where needed in the bottom of the pond. The gates and dam at the Clarendon Mills have also been cared for, and the drainage ditches along the margin of the reservoir have been maintained. About 115 acres of the reservoir site, including a strip 50 feet wide along the shore, have been cleared. The small trees and shrubs that have sprung up on the area from which the soil has been removed have been pulled or grubbed, and the brush has been mowed on the 50-foot strip along the shore of the reservoir where it had previously been cleared.

The maximum force employed on such work was 35 men and 1 horse, for the week ending July 20, 1901.

In addition to the engineering work connected with the estimates and inspection of the removal of soil, the following work has been done: For the guidance of the inspectors, the organic matter in 594 samples of soil has been determined, as well as the rate of filtration through 20 samples. The limit of area from which soil is to be removed along the margin of the reservoir has been staked out for 7.9 miles. Preliminary estimates of cost, plans, specifications and contract drawings were made for Contract No. 210. Topographical surveys and plans have been made of 87 acres of shallow flowage and steep slopes along the margins of the reservoir, and many cross-sections have been taken and plotted. The proper treatment of the shallow flowage and steep slopes has been studied. There have been 191 construction benches established.

CONTRACTS, WACHUSETT RESERVOIR.

Contract 166, Nawn & Brock.

Excavating Soil from Section 6 of the Wachusett Reservoir and building the Easterly Portion of the North Dike, Boylston, Clinton and West Boylston.

On June 13, 1899, a contract was made with Nawn & Brock for completing the easterly portion of the North Dike, with the exception of the slope paving. The material for this purpose, with the exception of comparatively small amounts of sand and gravel, was to be obtained by removing the soil from some 1,700 acres known as Section 6 of the Wachusett Reservoir. By far the greater part of this section is located west of the South Clinton station and south of the Central Massachusetts Railroad. There is, however, a large area included in the section north and east of the South Clinton station, and a small area, comprising the bed of Coachlace Pond, south of the dike. The last-mentioned areas were sublet in 1899, but the subcontract was terminated on August 20, 1901, and the work was continued by the principal contractors.

Before beginning the removal of soil in the spring the subcontractors laid tracks upon which the soil could be hauled by locomotives to the dike, and all of the soil removed by them was hauled over this railway instead of up the incline used the previous year; otherwise there was no material change in the method of doing the work up to the time when the work was taken under the control of the principal contractors.

The principal contractors have prosecuted their work during the year in substantially the same manner as formerly, hauling the soil from all areas up their double-track railway to the dike. On the intervale and other low and comparatively level areas, where it has been practicable to do so, the contractors have loaded the soil directly into cars, throwing the track as the work progressed. On other portions of the work, where this method was impracticable, it was hauled to dumping platforms and there dumped into cars. The soil has been deposited in the easterly portion of the dike.

The total number of carloads hauled during the year from the area south of the Central Massachusetts Railroad has been 227,947, amounting to 750,744 cubic yards; this, with the 325,598 carloads hauled during the previous years, amounting to 1,126,719 cubic yards, makes a total of 553,545 carloads, amounting to 1,877,463 cubic yards.

The total number of carloads hauled during the year from the area north of the Central Massachusetts Railroad has been 69,468, amounting to 205,664 cubic yards; this, with the 42,045 carloads hauled during the previous years, amounting to 98,520 cubic yards, makes a total of 111,513 carloads, amounting to 304,184 cubic yards.

Earth, consisting of either sand or gravel, has been deposited as needed to construct an embankment on the water side of the dike, with a thick gravel facing on the water slope; also to complete the secondary embankment which forms a part of the dike further to the north. There have been 28,344 cubic yards of earth and 356 cubic yards of gravel used for this purpose during the year, which, added to 16,906 cubic yards of earth and 780 cubic yards of gravel used in previous years, make totals at the end of the year of 45,250 and 1,136 cubic yards, respectively.

There have been 1,575 cubic yards of earth deposited as a covering over muck which was so deep that it was deemed inadvisable to excavate it; this amount, added to the 167 cubic yards used for a similar purpose in previous years, makes a total of 1,742 cubic yards.

The plant used by the principal contractors after they assumed the entire work included 18 8 to 12 ton locomotives, 500 3½ cubic yard dump cars, 20 1.7 cubic yard dump cars and 20.6 miles of 3-foot-gage track.

The total amount of work done under this contract has been: —

	To December 31, 1900.	For the Year 1901.	Total to December 31, 1901.
Clearing and grubbing (acres), ...	351	272	623
Soil excavation (cubic yards), ...	1,249,545	957,108	2,206,653
Earth excavation (cubic yards), ...	17,201	29,919	47,120
Gravel excavation (cubic yards), ...	780	356	1,136

The maximum force employed was 980 men and 108 horses, for the week ending August 17, 1901.

Contract 183, Long & Little.

Excavating Soil from Section 7 of the Wachusett Reservoir, and building a Part of the Westerly Portion of the North Dike, Clinton and Boylston.

This contract was made on December 12, 1899, and called for the excavation of soil from about 313 acres of the Wachusett Reservoir site, known as Section 7, embracing the intervale north of the Central Massachusetts Railroad, the steep slopes on the northerly side of the intervale between South Clinton and Sawyer's Mills, the intervale and slopes on both sides of Cunningham's Brook, and a portion of the Catholic Cemetery in Clinton. The contract also provides for the completion, with the exception of the slope paving, of the northeasterly 2,400 feet of the westerly portion of the North Dike, the completion of the main embankment of sand and gravel, and the partial construction of the soil embankment for an additional 1,700 feet.

The entire work between South Clinton and Sawyer's Mills has been completed, and the use of the incline and hoisting engine for hauling the soil to the top of the bluff, midway between South Clinton and Sawyer's Mills, has been abandoned. Of the northeasterly part of the dike, 1,200 feet have been completed.

The plant employed, exclusive of horses and carts, has included 1 50-horse-power hoisting engine, 4 12 to 15 ton locomotives, 100 2½ cubic yard dump cars and 3.4 miles of 3-foot-gage track.

The soil along Cunningham's Brook and in the Catholic Cemetery has been removed partly by the car plant and partly by a force working with dump carts. On this section no soil has been hauled to dumping platforms and dumped into cars, as the carts have transported the soil directly to the dike, except a small amount which has been loaded into carts and dumped along the sides of the track and subsequently reshovelled into cars. On the steep slopes between South Clinton and Sawyer's Mills wooden chutes or troughs lined with sheet iron were used, the laborers shovelling the soil directly into the chutes, where it would slide to the track at the bottom of the slope.

During the year the car plant has removed 74,266 carloads of soil, containing 205,543 cubic yards; during the previous year 63,563 carloads, containing 176,587 cubic yards; making a total at the end of 1901 of 137,829 carloads, containing 382,130 cubic yards of soil.

There have been 28,710 cubic yards of earth used to cover deep muck during the year, and 1,700 cubic yards in the previous year, making a total at the end of 1901 of 30,410 cubic yards. A small amount of gravel for facing the dike was excavated from a pit south of the cemetery ridge, but, as the gravel proved unsatisfactory, a new pit was opened between Sandy Pond and the cemetery. Most of this gravel was taken to the dike with trains.

The total amount of work done under this contract has been: —

	To December 31, 1900.	For the Year 1901.	Total to December 31, 1901.
Clearing and grubbing (acres), . . .	46	90	136
Soil excavation (cubic yards), . . .	227,679	252,264	479,943
Earth excavation (cubic yards), . . .	1,864	28,710	30,574
Gravel excavation (cubic yards), . . .	655	26,930	27,585

The maximum force employed was 308 men and 49 horses, for the week ending May 18, 1901.

[illegible] and Building a Part [illegible]

[illegible] well [illegible] section [illegible] contract [illegible] complete the [illegible] cubic [illegible] removed embraced [illegible] grubbing, [illegible] Sawyer's [illegible] considerable tract [illegible] Massachusetts [illegible] about [illegible] of the [illegible] covering [illegible] above.

[illegible] The [illegible] and that [illegible] removed in [illegible] Mills, where [illegible] to the foot [illegible] West Boyls- [illegible] decline by a [illegible] decline to the [illegible]

[illegible] begun October 16, [illegible] carloads, equal [illegible] The car plant [illegible] dump cars, 1 [illegible] foot-gage track. [illegible] this contract has been: —

[illegible]	54
[illegible]	100,553
[illegible]	10,600

[illegible] was 189 men and 33 horses, for the week ending November [illegible]

LAND SURVEYS.

Surveys have been made of the portion of Sterling west of the Stillwater River, referred to in chapter 445 of the Acts of the year 1897, also a plan of this land on a scale of 500 feet to an inch. Considerable additional work has been done in revising real estate plans, setting stone monuments and preparing plans for the use of the Attorney-General in land suits.

REAL ESTATE, CARE AND DISPOSAL.

Rents have been collected on houses in the possession of the Board, and a considerable quantity of land products have been sold. Fences and stone walls have been built and repaired. Trees and bushes have been cleared for 34,000 linear feet along the margins of the land purchased by the Board for a fire guard; interior cart roads 15 feet wide have been cut out for 21,150 linear feet; and the brush has been mowed on the fire guards and cart roads previously cleared. During periods of drought, watchmen have patrolled the land to guard against fires. There have been 123 acres of woods and brush thinned for the improvement of the existing growth. The necessary clearing has been done on 103 acres, preparatory to tree planting the coming spring; 1½ acres have been cleared and grubbed for extending the nurseries on the south side of the reservoir; making the total area of tree nurseries under cultivation about 5 acres, on 2 acres of which white pine seeds have been planted during the year. These nurseries contained at the end of the year approximately the following: —

	Seedlings.
White pines from seeds planted in 1898, ...	100,000
White pines from seeds planted in 1899, ...	70,000
White pines from seeds planted in 1901, ...	515,000
Total, ...	685,000

In West Boylston 53 dwellings, 14 barns, 2 mills, 1 hotel and 1 hall, making a total of 71 buildings, have been torn down or removed during the year; this makes a total of 150 to the end of the year. Considerable work has been done in repairing buildings which it is desirable to retain.

[illegible] leave [illegible] been [illegible] to [illegible] health [illegible] tend [illegible] sidered [illegible] wastes [illegible] occupied [illegible] which

[illegible] into [illegible] brooks. [illegible] ed by [illegible] has been [illegible] inspection [illegible] population, [illegible] information, is in progress. [illegible] in the French Brook and Muddy Brook [illegible] The French Brook district contains a population of [illegible] people, with [illegible] horses and 270 head of cattle; Muddy Brook district, [illegible] people, with 11 horses and 215 head of cattle.

REMOVAL OF BODIES FROM ST. JOHN'S CATHOLIC CEMETERY.

As the work of excavating progressed at the cemetery, 30 additional bodies were found, and upon notification they were removed by representatives of the Cemetery Association. This makes a total of 3,872 bodies removed from the cemetery.

ENGINEERING.

In addition to the engineering work already enumerated and that necessarily connected with the contract and day-labor work in progress, the engineering force of the Reservoir Department has performed the following work: Levels of the ground at the Wachusett Reservoir, taken after the completion of the excavation, have been entered on the record sheets, and contour lines have been drawn covering an area of about 770 acres, making the total area of these final records at the end of the year 920 acres; measurements have been made from these sheets covering an area of 530 acres, for the purpose of determining the capacity of the reservoir; surveys, plans, estimates and cross-sections of proposed railroad changes at Oakdale have been made; gage readings have been taken at the storage reservoirs on the Wachusett watershed on the 1st and 15th of each month, and the storage at each date has been computed. Many tables and schedules have been prepared for the hearings before committees of the Legislature and before the special commission relative to compensation for the towns of Clinton, Holden and Sterling, and other lists have been made to determine the amount to be paid by the Board for taxes or in lieu of taxes to the towns of Clinton, Boylston and West Boylston. Much other work of a miscellaneous character has been done.

DAM AND AQUEDUCT DEPARTMENT.

T. F. RICHARDSON, *Department Engineer.*

The principal work in this department has been the construction of the Wachusett Dam, but early in June negotiations relative to the relocation of the Central Massachusetts Railroad reached a stage which warranted placing a force in the field to make the more accurate surveys required as a basis for constructing the road. The department also has charge of the maintenance and operation of the Wachusett Aqueduct and the Clinton Sewerage System.

The organization of the force has been modified by the transfer of Alexander E. Kastl, division engineer, from the Reservoir Department to this department, to take charge of the railroad surveys, and by the organization by transfer and otherwise of a party for this work. Chester W. Smith, assistant engineer, continued in charge of work at the Wachusett Dam. Ernest G. Hopson resigned his position as head draftsman at the Clinton office on June 6, to go into private practice; and, as the work in the drafting office had diminished somewhat, his place has not been filled. Elliot R. B. Allardice has continued in charge of the river and aqueduct gagings, and has the direct supervision of the maintenance of the Clinton sewerage plant.

The engineering force at the beginning of the year was 16, it reached a maximum of 26 in September, and at the end of the year numbered 21.

The main office of this department is in Clinton, and a branch office has been maintained near the Wachusett Dam.

WACHUSETT DAM.

The Wachusett Dam and the main contract for its construction, made on October 1, 1900, with the McArthur Brothers Company of Chicago, Ill., were fully described in the last annual report.

The contractor began work on October 11, and at the end of the year had done a large amount of work in installing plant, had excavated a small amount of material at the dam and had done considerable work in stripping at the quarry, 1¼ miles from the dam.

Plant.

At the beginning of the year work upon the compressor plant and cableways was in progress, and one cableway across the valley had been erected. On January 28 a second cableway, of the same dimensions and capacity as the first, was completed and put in operation.

Compressors and the pipes leading from them to the dam and quarry were finished early in April, and the power was first used at the quarry on April 13 and at the dam on April 18. Since these dates practically all of the machinery at both places, including cableways, derricks, pumps, drills, etc., has been operated by compressed air.

The compressor plant, which is located at the side of the Central Massachusetts Railroad, between the quarry and the dam, consists of two cross-compound Rand air compressors, which are operated by two compound condensing Corliss engines, rated at 500 horse-power each. The diameters of the steam cylinders are 18 inches and 34 inches, and of the air cylinders 20 inches and 34 inches; the length of the stroke is 42 inches. The two boilers which supply the steam are Cahall inclined water tube boilers, made by the Aultman & Taylor Machinery Company of Mansfield, O.

To supply the large quantity of water needed for cooling, condensing, etc., a 3-inch pipe line, about 3,550 feet long, has been laid from Clamshell Pond, which has an area of about 26 acres and an elevation sufficient to supply water to the inter-coolers of the compressors. To economize water as far as possible, the waste water is discharged into the far side of a reservoir several acres in extent, and after passing through this reservoir is again pumped to be used for cooling and condensing purposes. The main wrought-iron air pipe leading to the dam is 8 inches in diameter, and that leading to the quarry 6 inches in diameter.

From the time of starting until November 23, when night work was stopped for the season, the compressors were in operation day and night. The amount of power furnished has varied considerably, but has averaged about 600 horse-power for day shifts and about 370 horse-power for night shifts. The maximum amount used at any time was 850 horse-power.

A branch track, 5,490 feet long, from the Central Massachusetts Railroad to the dam site, was built in 1900. A part of this track serves as the main track from the quarry to the dam, but it was necessary to build an additional 3,030 feet, which was completed early in April. To carry this extension over the Central Massachusetts Railroad and Boylston Street, where there is an electric car line, a pile bridge about 800 feet long and having a maximum height of about 32 feet was built.

In order to get more working room at the quarry at a level about 40 feet higher than the first opening, a double switch-back track, about 3,300 feet long, was built, connecting the upper with the lower quarry; this was completed and put in operation late in August.

The main pumps at the dam were two 12-inch Worthington compound piston pumps, set on the up-stream and down-stream sides of the deep excavation for the dam, and most of the time the water was pumped into the large flume. These two pumps were capable of pumping all of the water which came into the excavation, but supplementary pumps were provided for emergencies and additional small pumps for pumping from the cut-off trench and for other local pumping.

To supply water for the use of the locomotive, mortar mixing, washing the rock foundation of the dam preparatory to building masonry, and other purposes, water has been pumped from the river to a tank 92 feet above it on the hillside; and to supply water for washing stones at the quarry, a pump at the central power station raises the water about 200 feet to a tank on the hill near the quarry, this tank being 152 feet above the track in the lower quarry.

A 60-ton, 10-wheel, standard-gage locomotive, 29 flat and gondola cars and 4 4-yard dump cars are used to haul stone and other material. In addition, there are 15 3-foot gage 2½ yard cars, which are used for various purposes.

A maximum of 8 derricks has been in operation at the dam and 8 at the quarry. Those at the quarry are unusually large, some of them having masts 82 feet high. The derricks at the quarry are operated by hoisting engines having 7 by 10 inch cylinders, and those at the dam by hoisting engines having 5½ by 8 inch cylinders. All of the derricks are equipped with bull wheels, by means of which the engineer swings the derrick, doing away with the use of tagmen.

The arrangements for supplying and mixing the materials used for mortar have been carefully made, with reference to economy in operation. Two cement storehouses, which have a capacity of 4,500 barrels, are situated near the head towers of the cableways, and close to the branch track over which the cement is brought. The sand bin, which has a capacity of 370 cubic yards, is located further up the hill, and so constructed that the sand will run into small cars on either of two tracks which pass under the bin. The sand track passes between the cement houses, above the level of the tops of the doors, and the sand can be dumped directly into a cubical mortar mixer 4 feet on a side, which has been installed immediately below the space between the cement houses. The cement can be wheeled from either cement house and dumped from a platform into the mixer. The mortar after being mixed is dumped into skips placed on small cars on a lower track, which are hauled by horses directly under the cableways and delivered by them upon the work.

To accommodate the better class of unmarried laborers, three large buildings have been built; two of these are for sleeping quarters, — each of which will accommodate nearly 80 men, — and the other contains a kitchen and dining room. For sleeping quarters the buildings are divided into small rooms, which are furnished with iron beds and mattresses, and at one end of each a recreation room is provided and at the other end bath tubs with hot and cold water. Many small buildings have been built to accommodate men with families; and an office, machine shop, storehouse, commissary and other small buildings have been erected.

Quarry.

In the early part of the year the work of stripping the quarry was in progress, and during the latter part of February a travelling derrick was erected to handle the rock excavated and to prepare a working face. Derricks with guys were installed as soon as a sufficient face had been obtained.

Early in June, when it was found that the poor quality of the rock at the far end of the quarry made it inadvisable to extend it in that direction, a second quarry opening was started, at a level 40 feet higher than the first. Five derricks have been in operation at the lower quarry, which it is intended to work from the level of the upper quarry down to a point 30 feet below the track. At the close of the season three derricks were in operation at the upper quarry, and work was in progress which would permit the placing of more derricks.

The stone obtained at the quarry is a muscovite granite, weighing 165 pounds per cubic foot, of good quality for splitting and cutting, and having substantially the same crushing strength as the Cape Ann and Quincy granites. All of the stone for rubble masonry and all of the ashlar used up to the present time have been obtained from this quarry.

Both large and small stones suitable for use in the masonry are loaded directly into large skips or scale boxes, placed upon flat cars, which are made into trains and hauled to the dam directly beneath the cableways; the skips are then lifted by the cableways and lowered to the point where the masonry is in progress. The average skipload of large stones equals about 2.3 cubic yards, and of spalls 1.9 cubic yards, solid measure.

Excavation at Dam.

At the beginning of the year one cableway was in operation, removing material from the deep excavation in the bottom of the valley. Late in January, when the second cableway was put in operation, the force was increased. On February 28, night shifts were organized, fourteen electric arc lights being provided to light the work. The excavation was continued with day and night shifts until June 8, soon after the masonry was started, and since that time most of the excavation has been done by the night shifts.

The material for about 30 feet below the bed of the river was sand and gravel, which was easily handled. Below this level, from a large part of the area for rather more than 20 feet to the ledge, boulders, large and small, packed very close together, with the interstices filled with cemented gravel, were encountered. This condition made the excavation somewhat difficult. Some of the boulders were of enormous size, one containing 621 cubic yards.

The earth excavation was started with slopes of 1½ horizontal to 1 vertical, and continued with this slope to the bottom on the up-stream side; but on the down-stream side the boulders and cemented gravel were so firm that the lower part of the excavation was made nearly vertical. The slopes were laid out so that they would intercept the surface of the rock 20 feet above the up-stream face of the masonry, and generally 15 feet from the down-stream face. The maximum width of the excavation at the top of the pit was 376 feet, and at the surface of the ledge 211 feet. The maximum amount of water pumped was about 4,000,000 gallons per day. There was some caving of the up-stream slope, which was composed largely of sand; but this was treated when it occurred, so that the slopes were maintained without much difficulty, and the whole excavation was completed without accident or serious delay.

As the earth excavation progressed, the granite cliff about 40 feet high on the westerly side of the gorge was uncovered and found to be overhanging, as indicated by the preliminary borings. The overhanging part and some additional rock were removed by blasting. At one point it was necessary to blast to a distance of 30 feet back from the face of the cliff.

The ledge rock in the bottom and on the easterly side of the gorge is schist, sometimes gray and quite hard, and at other places black and rather soft, but impervious to water. The schist at the contact with the granite, for a varying width, ranged from about 4 feet at the cut-off, where it is quite soft, to a maximum of about 20 feet, where it is somewhat harder; but the junction with the granite seemed to be a perfect one in nearly all cases, and the schist is water-tight and sufficiently strong to resist any pressures which may come upon it.

After reaching the rock, the excavation was continued as far as necessary to obtain solid rock nearly free from seams. The average depth of excavation in the rock has been about 13 feet, and the cut-off trench, 20 feet in width, has been excavated to an additional depth of about 14 feet. In order not to disturb the walls of the cut-off trench, lines of 3-inch holes, 6 inches apart on centres, were drilled to the bottom of the trench; the rock in the centre of the cut-off was then removed by careful blasting, and large steel wedges were used in the side holes to remove the rock near the walls of the cut-off. By this method of operating, the walls were generally left vertical and were not shattered.

A deep recess, about 20 feet in width, was cut into the face of the granite cliff, with considerable difficulty and delay, by the same methods.

Under the provisions of the specifications the last part of the rock excavation before building the masonry was to be done by barring and wedging, without blasting. In this way all loose or shaky rock was removed, the average depth of such excavation being about 1.5 feet. The rock was then scrubbed with brooms and thoroughly washed with water.

The excavated material was removed by the cableways, and was used in part for grading the grounds on the westerly hillside near the bastion, where a considerable fill is to be made, but most of it was placed on cars and dumped along the quarry track.

Considerable earth was excavated from the site of the power house, pool and conduits, and used to refill the deep excavation on the down-stream side of the dam, after the masonry had risen high enough to permit this to be done. Some of the material excavated from the site of the dam has also been dumped at this place, and the filling has been raised nearly to the level of the top of the masonry.

At the end of the year, after work upon the masonry had been stopped, earth excavation was in progress in the waste channel and

in the trench for the dam on the westerly side of the large fi
The material from the place last named was dumped on the
stream side of the dam, between a filling of clayey material
viously made against the up-stream face of the masonry an
slopes of the deep excavation.

Masonry.

The first stone at the dam was set June 5, and the building
masonry was continued until December 5, when it was stop
account of the cold weather. The largest number of derr
operation has been 7 on the masonry of the dam and 1
masonry of the spillway below the pool.

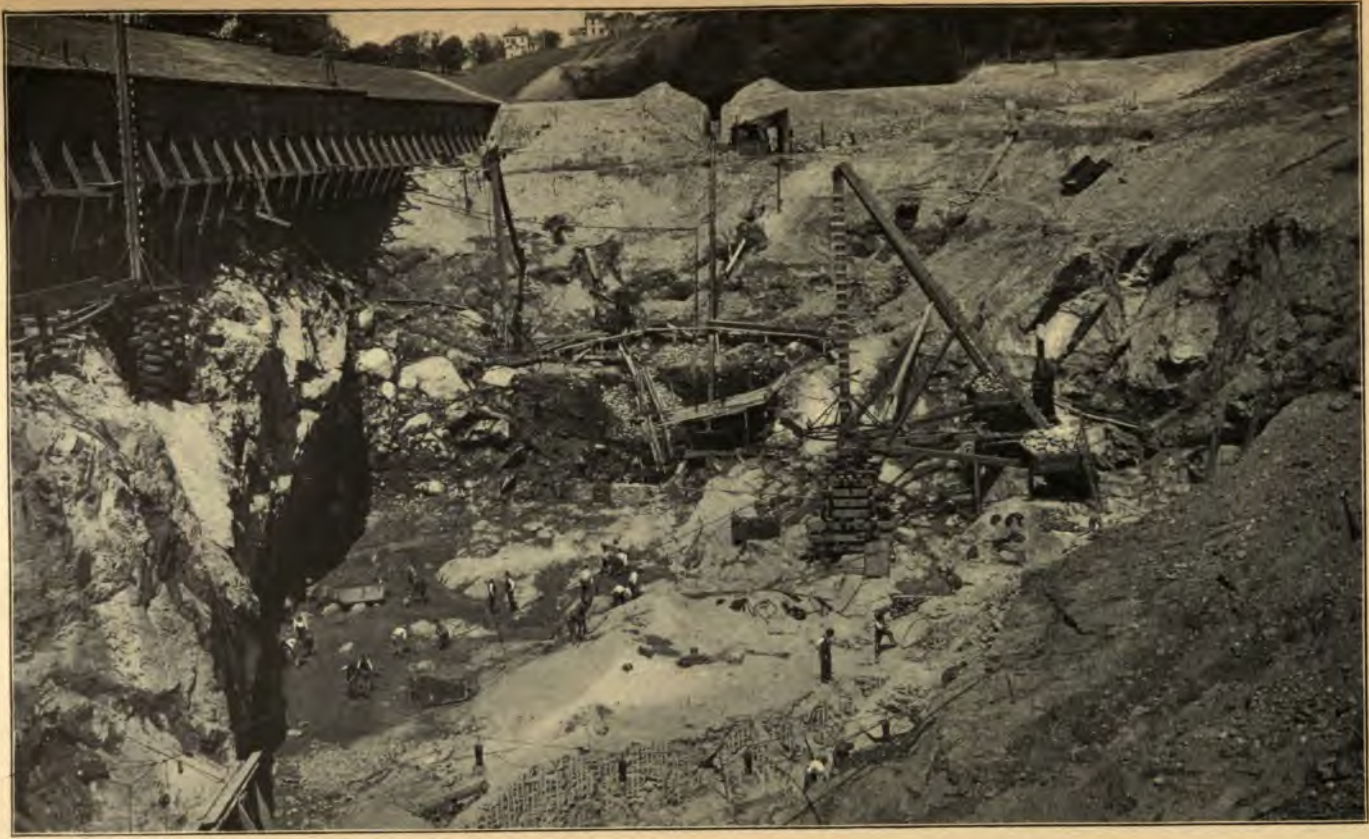
Masonry used for filling the cut-off and that immediat
the rock over the whole foundation of the dam has been laid
land cement mortar, mixed in the proportion of 2 parts o
1 of cement. The use of Portland cement has been con
greater heights, so as to include all masonry in a triangul
below an inclined line 30 feet above the bottom of the gor
down-stream face of the dam, and intersecting the botto
gorge 150 feet up stream from the lower edge of the d
Leaving the bottom of the excavation, however, the Portl
mortar was generally mixed in the proportion of 2½ pa
to 1 of cement.

Above the limits of the Portland cement work an
mortar has been used, mixed in the proportion of 2 par
1 of cement, except that toward the close of the seaso
work might be affected by frost, Portland cement mort
the proportion of 3 parts of sand to 1 of cement, was u

In all, 17,708 barrels of Giant Portland cement and
of Union natural cement have been used in the work
cement being manufactured by the American Cemen
Egypt, Pa.

The stone in the triangular section of the dam, w
cement was used, was laid with beds inclined upw
down-stream face of the dam at the rate of 1 vertical
Above this section the stones in the down-stream
face had their beds inclined upward at the rate o
horizontal.

On the down-stream side of the dam, where the



WACHUSETT DAM—Excavation at Time of Beginning Masonry Construction.

in the trench for the dam on the westerly side of the large flume. The material from the place last named was dumped on the up-stream side of the dam, between a filling of clayey material previously made against the up-stream face of the masonry and the slopes of the deep excavation.

Masonry.

The first stone at the dam was set June 5, and the building of the masonry was continued until December 3, when it was stopped on account of the cold weather. The largest number of derricks in operation has been 7 on the masonry of the dam and 1 on the masonry of the spillway below the pool.

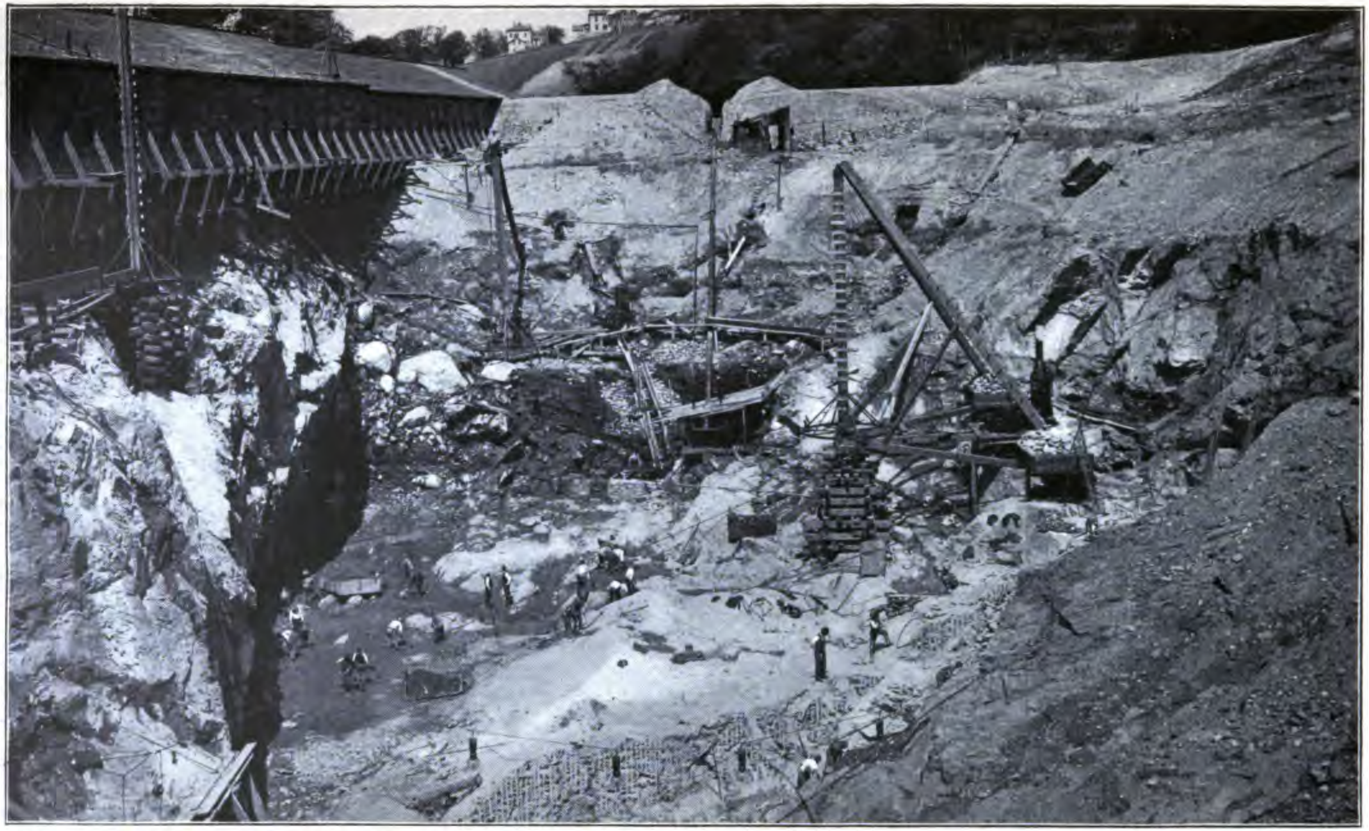
Masonry used for filling the cut-off and that immediately above the rock over the whole foundation of the dam has been laid in Portland cement mortar, mixed in the proportion of 2 parts of sand to 1 of cement. The use of Portland cement has been continued to greater heights, so as to include all masonry in a triangular section below an inclined line 50 feet above the bottom of the gorge at the down-stream face of the dam, and intersecting the bottom of the gorge 150 feet up stream from the lower edge of the dam. After leaving the bottom of the excavation, however, the Portland cement mortar was generally mixed in the proportion of 2½ parts of sand to 1 of cement.

Above the limits of the Portland cement work natural cement mortar has been used, mixed in the proportion of 2 parts of sand to 1 of cement, except that toward the close of the season, when the work might be affected by frost, Portland cement mortar, mixed in the proportion of 3 parts of sand to 1 of cement, was used.

In all, 17,703 barrels of Giant Portland cement and 8,892 barrels of Union natural cement have been used in the work, both brands of cement being manufactured by the American Cement Company of Egypt, Pa.

The stone in the triangular section of the dam, where Portland cement was used, was laid with beds inclined upward toward the down-stream face of the dam at the rate of 1 vertical to 4 horizontal. Above this section the stones in the down-stream half of the dam have had their beds inclined upward at the rate of 1 vertical to 6 horizontal.

On the down-stream side of the dam, where there was a vertical



WACHUSETT DAM — EXCAVATION AT TIME OF BEGINNING MASONRY CONSTRUCTION.

face of large boulders and cemented gravel which was very firm indeed, and where the granite cliff was overhanging, masonry laid in natural cement mortar was filled in against the cliff and between the down-stream face of the dam and the boulders and cemented gravel to a height of 28 feet, close to the granite cliff, and a diminishing height as the distance from the cliff increased. This filling was made for the double purpose of supporting the overhanging cliff, which farther up stream would have the weight of a portion of the dam upon it, and in part to furnish a solid buttress which would resist any tendency of the dam to slide upon its foundation. The area of this buttress, where in contact with the boulders and cemented gravel, was about 830 square feet.

In all cases where there was any advantage in doing so, the masonry at the down-stream face of the dam was built out against the sides of the rock excavation. In laying the stones, great care has been taken to fill every joint between the stones with mortar, and spalls have been used to fill between the large stones to the greatest extent consistent with the proper bedding of the stones.

The masonry of the dam as far as built is made up of 54 per cent. in volume of large stones, 17 per cent. of spalls and 29 per cent. of mortar. The average size of the stones used has been quite large, some containing as much as 3 cubic yards.

The up-stream face of the dam has been built of squared stones, having joints not wider than 1 inch, and these joints have been raked out for 2 inches back from the face and pointed with mortar composed of 1 part of Portland cement and 1 part of sand.

The down-stream face of the dam is in irregular steps, the inner angles of which conform to the required slope of the face.

The largest amount of masonry laid in the dam in any week was during the week ending October 12, when 7 derricks were in operation and 1,767 cubic yards of masonry were laid.

Following are some elevations, which will give an idea of what has been and what remains to be done: —

	Feet.
Elevation of lowest point in cut-off trench,	187
Elevation of bottom of masonry in deepest part of gorge, not in cut-off trench,	208
Elevation of top of masonry built,	255
Elevation of bottom of river channel,	269
Elevation of bottom of pipes through dam,	284
Elevation of top of dam,	415

A part of the rubble masonry and of the ashlar paving of the apron below the spillway has been built. Some of the paving stones are about 8 feet long and 4 feet deep, and contain over 60 cubic feet.

Excellent sand has been obtained from land of the Commonwealth, about 3/5 mile from the dam, to which it is hauled by teams.

Mortar has been mixed in the cubical mixer in batches of about 1 cubic yard, which, in the case of a 2-to-1 mixture, requires about 3½ barrels of cement and 7 barrels of sand. Two batches are usually dumped into a skip and sent down upon the work together.

Comparison of Work Done with Total Amount.

The following table gives the total quantity of work done to the end of the year and the estimated total quantities: —

	Work done December 31, 1901.	Total Work.
Earth excavation (cubic yards),	43,000	267,300
Rock excavation (cubic yards),	24,370	100,000
Rubble stone masonry (cubic yards),	28,486	265,000
Ashlar masonry (cubic yards),	65	10,300
Dimension stone masonry (cubic yards),	–	2,900
Brick masonry (cubic yards),	–	1,300
Concrete masonry (cubic yards),	–	8,300

The above statement does not represent fairly the relation between the work done and the total work, because of the great amount of work done in installing the plant, opening the quarry and organizing the work; moreover, the most difficult part of the work has been accomplished.

The maximum force employed by the contractor has been 344 men and 22 horses, for the week ending July 20, 1901.

MORTAR EXPERIMENTS.

In view of the very large amount of mortar to be used in the dam and the importance of having it as water-tight and strong as possible, extensive experiments were begun early in the year, to determine the permeability and strength of mortars made of the natural and Portland cements which were to be used in the construction of the dam, mixed with different proportions of coarse and fine sands.

The experiments on permeability were made by placing the mortar in cast-iron cylinders, 22 inches long and about 6 inches in diameter. After the mortar had set, caps were bolted to the tops of the cylinders and water was admitted to the cylinders between the caps and the mortar with a pressure of 74 pounds to the square inch. There were 144 cylinders used in the experiments, and the apparatus was so arranged that the water pressure could be applied to 24 cylinders at a time. The applied water was first filtered through sand, to remove all suspended matter.

There were 1,494 briquettes made and broken, to determine the tensile strength of the mortars. It was found that the use of a sand with a very large proportion of coarse particles and a much smaller percentage of the finer grades makes a mortar both less permeable and stronger than where a larger proportion of the finer grades is used, provided the proportion of sand to cement does not exceed 3 to 1.

In addition to the experiments upon permeability and strength of mortars, other experiments were made to determine the relative strength of mortars used immediately after wetting and mixing, and when used at different intervals up to two hours after they are first wet and mixed. These experiments were very extended, as they were made with mortar mixed with different grades of sand, with Portland and natural cement, with slow-setting and quick-setting cement, and with mortar that was worked continuously from the time of mixing until it was put into the molds, and also with mortar which was not worked after it was mixed until just before it was put into the molds. The briquettes were broken at the end of fourteen days, twenty-eight days, and three months after mixing.

It was found that when the cements, both Portland and natural, were so manufactured as to take the initial set slowly, the strength of the mortar was not diminished by a delay of two hours in putting it into the molds; and when the mortar was worked continuously to the time of filling the molds, there was an increase in strength occasioned by the delay. When the cements were so manufactured as to take the initial set quickly, the results obtained with the Portland cement were not materially different from those obtained with the slow-setting cement, except that when the mortar was not worked there was a slight loss of strength in the briquettes molded at the end of one and a half and two hours, and at no time was there much gain in strength occasioned by delay in filling the molds. The results obtained with the quick-setting natural cement were less favorable, as the briquettes broken at the end of fourteen days showed a great loss of strength when there was much delay in molding the briquettes. At the end of three months, however, the briquettes made with mortar which had been worked continuously from the time of mixing showed slightly greater strength than that put into the molds immediately, and the loss of strength of the mortar not worked was not very marked except for the one and a half and two hour periods.

RELOCATION OF CENTRAL MASSACHUSETTS RAILROAD.

Beginning in June, a careful survey was made for a line of railroad, leaving the present track of the Central Massachusetts Railroad midway between the Berlin station and the crossing over the New York, New Haven & Hartford Railroad, curving to the north and running east of the New York, New Haven & Hartford Railroad to a junction with the Worcester, Nashua & Portland division of the Boston & Maine Railroad, about one mile north of Clinton. Much work was done in connection with the line surveyed, to prepare it for construction, because there was a strong probability that this line would be adopted. It has not, however, been adopted.

In the latter part of the year estimates of cost were made for two other lines, which pass north of the reservoir and connect with the Worcester, Nashua & Portland division.

GAGINGS OF THE SOUTH BRANCH OF THE NASHUA RIVER.

Accurate and continuous gagings of the South Branch of the Nashua River, at a point in Clinton about 1½ miles below the Wachusett Dam, have been made since July, 1896, but the results have not heretofore been published. Tables giving the results by months may be found in Appendix No. 3, tables 9 and 10.

The gagings are intended to show the quantity of water that would have flowed past the gaging station if no water had been diverted through the Wachusett Aqueduct, and for nearly all of the time the quantity that would have flowed if there had been no mill and other storage reservoirs upon the watershed.

As accurate gagings of streams are rare, it is thought desirable to describe in some detail the methods of measurement.

Gagings of Flow in River.

The quantity of water passing down the river bed has been gaged at a point near the Water Street bridge in Clinton. Just above this bridge there is an unused dam which has been partly demolished, but at which there is still a decided fall, so that the height of the water above it, when a given quantity of water is flowing, is affected but little if any, under all ordinary conditions, by the condition of the stream below the dam as regards obstructions from weeds in summer and ice in winter.

Above this dam a recording float gage was established, to give the height of the water accurately and continuously. Just below the dam and bridge a gaging section was established, having a plank bottom, and so arranged that the velocity is sufficient for accurate current meter gagings. When the flow of the river is very small, owing to the diversion of the water through the aqueduct, arrangements have been made to diminish the width of section through which the water flows, and thereby produce a sufficient depth and current for meter measurement.

By a sufficient number of meter measurements at all stages of the river, a curve was determined which showed the quantity of water corresponding to all heights on the recording gage. The relation between the quantity and the gaged height is frequently checked throughout the year.

The current meter used was originally rated, and the rating has since been checked from time to time at a well-arranged rating apparatus at Sandy Pond.

From July 1, 1896, when the gagings were begun, to July 15, 1896, the recording gage was not in operation, but an average of eight observations of height was made daily. In February, 1900, on account of a great flood which overflowed the bank of the river where the gage-house and gage were located, it became necessary to remove the gaging apparatus, and there were two days when the heights were not kept continuously throughout the twenty-four hours; otherwise, the recording gage has been in continuous operation.

Gagings of Flow in Aqueduct.

The first diversion of water from the river through the aqueduct was on March 7, 1898. At the lower end of the aqueduct a weir was established with a recording float gage, providing for a continuous record of the height of water flowing over the weir. A current meter station was established for gaging the flow through the aqueduct, and the weir was calibrated by many measurements with the current meter at various depths of flow. The quantity of water flowing through the aqueduct is, therefore, very accurately measured. In the lower stages of the river nearly all of the water passes through the aqueduct.

Storage Reservoirs.

There are upon the watershed 14 storage ponds and reservoirs, nearly all controlled by the mills, the capacities of which have been determined. The draft from these reservoirs materially increases the flow of the river in the drier portions of the year, and the flow diminishes while they are filling. These reservoirs, and their total capacities as determined by surveys, are as follows: —

NAME OF RESERVOIR.	Storage Capacity (Gallons).
Bartlett Pond,	48,400,000
Chaffin Pond,	99,600,000
North Eagle Lake,	48,400,000
South Eagle Lake,	192,000,000
Hackett's Pond,	27,600,000
Kendall Reservoir,	82,200,000
Musquapoag Pond,	61,900,000
Paradise Pond,	111,700,000
Pine Hill Reservoir,	118,700,000
Quinepoxet Pond,	275,600,000
Stuart's Pond,	58,800,000
East Waushacum Pond,	144,000,000
West Waushacum Pond, east of railroad,	170,000,000
West Waushacum Pond, west of railroad,	32,900,000
Total,	1,471,800,000

In addition to the above, there are some small ponds and reservoirs that were not surveyed, but their aggregate capacity is so small that they would not materially affect the flow in the river.

Observations of the heights of water in the reservoirs included in the table have been taken twice each month, usually on the 1st and 15th days, during the following periods: June 1 to November 15, 1897, inclusive; June 1 to November 1, 1898, inclusive; June 1, 1899, to January 15, 1900, inclusive; and continuously since June 1, 1900.

It will be noticed that no observations of the heights of reservoirs were taken in 1896, nor were any taken during the winter and spring months, until after the spring of 1900. The omission of the observations of the storage reservoirs in the summer and autumn of 1896 materially affects the records for that period; but the omission of observations in the winter and spring of several years causes little or no error, because at such times the reservoirs are usually full or nearly full, and the flow of the streams is comparatively large.

As already indicated, the aggregate quantity flowing in the river at the gaging station and in the aqueduct is corrected for the amount drawn from or added to storage, so that the records give as nearly as possible the actual flow of the river as it would be in its natural condition.

The change in storage during the month preceding and following the observed heights has been estimated; and during the remainder of the winter and spring months, when there were no observations, it has been assumed that the reservoirs were full.

Area of Watershed.

The area of the watershed above the Wachusett Dam was determined by the State Board of Health, from the topographical map of the State, after a careful reconnaissance of the divide for its whole length, to be 118.23 square miles. A change in the location of the North Dike from that originally proposed has added .08 of a square mile, and an additional area of .69 of a square mile, draining to the river between the Wachusett Dam and the gaging station, makes the total area of the watershed at the gaging station 119 square miles.

REAL ESTATE, CARE AND DISPOSAL.

Rents have been collected and repairs made on the houses belonging to the Board in the neighborhood of the dam and of the Clinton sewerage filter-beds in Lancaster.

CEMENT TESTS.

Tables of cement tests are published in Appendix No. 2. They contain long-time tests of cements used from 1896 to 1900, inclusive, and the usual tests of cements used in the Wachusett Dam and the Weston Aqueduct in 1901.

SUDBURY DEPARTMENT.

DESMOND FITZGERALD, *Department Engineer.*

The work in this department relates mainly to the maintenance and operation of the Sudbury and Cochituate works, including the aqueducts and Chestnut Hill Reservoir.

The work of construction in this department during the year has been connected entirely with the improvement of certain shallow arms of Lake Cochituate, known as the Pegan Brook and Snake Brook meadows. This work was required by chapter 509 of the Acts of the year 1901, which was approved June 14. Mr. FitzGerald and his assistants have also devoted much time to the case of the Nashua River Paper Company *v.* Commonwealth of Massachusetts, for damages caused by the diversion of the waters of the Nashua River, and to other water cases.

Charles E. Haberstroh, assistant superintendent at South Framingham, is in immediate charge of the storage reservoirs and other works on the Sudbury and Cochituate watersheds and of the Sudbury and Cochituate aqueducts.

Charles W. Sherman, assistant engineer, is Mr. FitzGerald's principal assistant in the Boston office.

Benjamin F. Goodnough, assistant engineer, has been connected with the department all the year, and during the last half has been in immediate charge of the improvements at Lake Cochituate.

The engineering force engaged upon construction has varied from 1 to 5.

The main office of this department is in Boston, and a branch office has been maintained at South Framingham.

IMPROVEMENT OF LAKE COCHITUATE.

Before the lake was raisèd above its original level the Pegan and Snake Brook meadows were comparatively dry, but by successive raisings of the water surface they were covered to a depth of about 6 feet when the lake was full. When the lake was drawn down, in times of drought, the mud surfaces were exposed, and at such times odors arose from decaying vegetation and from the exposure of the mud to the sun.

A plan for abating this trouble, and more particularly the trouble at the Pegan Meadow, was suggested by the engineers of the Metropolitan Water and Sewerage Board, in which it was proposed to maintain a dam at the outlet of the meadows which would have its top about 2 feet below the level of high water, so that the water from the lake could circulate freely into the portion of the lake behind the dam for several months of the year when the lake was full, and yet the dam would maintain a considerable depth of water over the meadows when the lake was drawn down, and thus prevent offensive conditions.

This plan, which would have cost but a few thousand dollars for its execution, was not satisfactory to the petitioners to the Legislature, and the act already mentioned was passed, providing for the excavation of the meadows to a level which would give practically 10 feet of water over them at high water.

The act further provided that the work should be done within two years from its passage; and that, in addition to the excavation of the meadow, the banks should be improved so that mud deposits should not be exposed thereon at low stages of the water; and that, if it should prove impossible to excavate the meadows to the specified depth for the sum of $100,000, the work should be prosecuted to such an extent "as may reasonably be done" for this sum.

The time for executing this work was extremely short, because it could be prosecuted only after the lake had been drawn down; and the rainfall during the last summer was so large that it soon became evident that it would not be feasible to improve more than the Snake Brook Meadow, which is the smaller one, during the year, although certain preliminary work could be done at the Pegan Brook Meadow, so that it could be pumped dry early in the summer of 1902 and completed in that year.

The plan of operation was rendered difficult because it was necessary to provide for taking care of large quantities of dirty and possibly polluted water without discharging it into the lake in such a way as to endanger the water supply.

The necessary surveys, soundings, plans and specifications were begun soon after the passage of the act; and as soon as the water in the lake had receded sufficiently, the work of construction was begun.

Snake Brook Meadow.

The arm of Lake Cochituate known as the Snake Brook Meadow covers an area of 28.7 acres, of which 17.5 acres are in the town of Wayland and 11.2 in the town of Natick. Plans having been prepared and the lake having receded sufficiently, it was decided on August 20 to proceed with the excavation of this meadow, with a view to completing it before the lake filled again. On the next day after this decision the actual work of construction began, in the building of a dam at the outlet of the meadow, to separate it from the main body of water in the lake. A 15-inch centrifugal pump was installed upon this dam, and on September 1 pumping from the meadow into the lake was begun. A 6-inch centrifugal pump was also erected to do the pumping after the meadow had been laid bare. To reduce the amount of water to be pumped, Snake Brook was diverted from its natural course at a point about half a mile easterly from the meadow. By the end of the first week in September the water had been lowered so that the meadow was exposed.

In response to a request for proposals for doing the work, eight proposals were received on September 10, and the contract was awarded to Long & Little of Leominster, Mass., the lowest bidders, at 24 cents per cubic yard for mud excavation and 25 cents per cubic yard for gravel facing. By the terms of the contract the Board was to continue to do the pumping, and was also to continue the work, already begun, of excavating main ditches through the meadow.

As the water to be pumped after the excavations were begun would necessarily be unfit to be discharged into the lake, a small wooden flume, about 1,060 feet in length, was provided for conducting the water pumped in a westerly direction, following a road across the lake, to a point where it would flow away from the lake into a stream below its outlet. A heavy rainfall of 2 inches on October 14 was cared for without flooding the contractors' work.

The work of ditching the bottom was carried on by a day-labor force, while the contractors were making their preparations. On September 30 the actual work of excavating the bottom was begun, with a small force, which was gradually increased to about 90 men on October 19.

As the amount of money available for making the improvements at Lake Cochituate was thought to be insufficient for excavating to the full depth required by the act, it was intended to excavate the

Snake Brook Meadow to a level 9 feet below high-water mark. The mud was everywhere excavated to this depth; but a sandy bottom was encountered at a somewhat higher level over a portion of the work, and this was not excavated. At the end of the year nearly all the excavation had been completed and the gravelling of the embankments had been begun. So little remains to be done that the work can probably be finished early in 1902, before the lake rises.

Pegan Brook Meadow.

The arm of Lake Cochituate known as Pegan Brook Meadow covers an area of 51.3 acres, and is situated in the town of Natick. The plan finally adopted for the improvement of this meadow involves the excavating of the meadow and the disposal of the material excavated in embankments to be faced with gravel, as at Snake Brook Meadow. As already stated, the amount of work involved was so great and the lake lowered so slowly that it was not feasible to attempt the main work in 1901, but much preliminary work has been done, so as to insure a long working season in 1902.

A temporary dam, about 700 feet in length, has been built at the site of an old dam, to separate the meadow from the lake. The top of this dam is above high-water mark, so that the meadow can be laid bare by pumping, even if the lake is full or nearly so after the spring freshets are over.

In addition to the building of the dam, a pump well about 10 feet square was sunk while the lake was low, near the line of the Boston & Albany Railroad, and a pump was erected to pump water during the work of construction through a 12-inch pipe under the railroad to filter-beds already in use in connection with the filtering of the waters of Pegan Brook.

The preliminary work at the Pegan Meadow was begun on September 28. In the last part of November, after the well and dam had been completed and nearly all of the meadow had been laid bare by the lowering of the lake, the stop-planks were placed in the sluiceway of the dam, and for the remainder of the year all water was pumped. As soon as the water had been lowered sufficiently, the actual work of constructing a large drainage ditch through the centre of the meadow was begun. On account of the heavy rainfalls in December the work was several times flooded, but at the end of the year was still under way. The water in the lake was then about 4 feet higher than the water inside the dam.

WESTON AQUEDUCT DEPARTMENT.

HORACE ROPES, *Department Engineer.*

The work in charge of this department includes the construction of the Weston Aqueduct and Reservoir and other works connected with it, extending from the Sudbury Reservoir in Southborough to a terminal chamber a short distance west of the Charles River in Weston, a distance of 13.44 miles.

At the beginning of the year the surveys and preliminary work necessary for the final location and design of this aqueduct and its appurtenances were still unfinished. The work of the year has included the substantial completion of these surveys, the letting of contracts and the construction of portions of the work.

The beginning of construction required a reorganization of the engineering force, as follows: —

Edward S. Larned, division engineer, transferred from the Sudbury Department to this department January 1, 1901, was placed in special charge of the masonry construction, with direct supervision of the inspection force and the cement-testing laboratory.

Four assistant engineers were assigned to divisions of the work, in charge of lines and grades, measurement of quantities and making estimates, and were given authority to direct in all matters pertaining to excavation and grading.

Dan B. Clark was placed in charge of the first division, comprising sections 1, 2, 3 and 4.

Frank E. Winsor was placed in charge of the second division, comprising sections 5, 6, 7, 8 and 9, and has also had charge of the drafting work at the main office in Saxonville.

Marshall Nevers was placed in charge of the third division, comprising sections 10, 11 and 12, and in the latter part of the year the westerly portion of Section 13.

George W. Booth was placed in charge of the fourth division, comprising sections 13, 14 and 15 and the Weston Reservoir, except the westerly portion of Section 13 during the latter part of the year.

All of the above engineers reported directly to the department engineer.

The total engineering force at the beginning of the year was 21, but with the growth of construction work this number was increased from time to time until it reached a maximum of 44 in August, including 12 engineering inspectors. There were also 6 masonry inspectors. On the approach of winter the force was reduced to 38 and 1 masonry inspector.

The main office of the department has been continued in Saxonville. It has been fitted up, and affords ample and convenient quarters for the general office, drafting rooms and cement-testing laboratory. The engineers of the second division also have their office in this building. Branch offices for the use of the first and third divisions, respectively, were rented in Framingham Centre and Wayland, and have been maintained since June 1. A branch office in Weston has been continued throughout the year for the use of the engineers of the fourth division. This office was moved on December 1 from unsuitable rented quarters to a house on Ash Street, which had been acquired by the Board through its purchase of land for the Weston Reservoir.

The day-labor force, consisting of a foreman and from 5 to 15 laborers, has been employed at different times during the year on a variety of preliminary work, such as the digging of test pits, making borings and rod soundings, and clearing timber and burning brush at the site of the Weston Reservoir.

General Statement.

From the beginning of the year the surveys and other preliminary work necessary for the final location and design of the aqueduct and its appurtenances were prosecuted vigorously. This work was so far advanced early in the spring that proposals were received on April 30 for the construction of the portions of the aqueduct which would require the longest time for their completion, and land upon which to build these sections of the aqueduct was taken May 17.

The preparatory work for other portions of the aqueduct was continued, and on August 27 proposals were received for the construction of the remainder of the masonry aqueduct. On November 21 proposals were received for the construction of the Weston Reservoir and the open channel above it.

The work now under contract comprises 9.14 miles of masonry aqueduct in open trench, 2.30 miles of aqueduct in five tunnels and 1.02 miles of open channel and reservoir, — a total of 12.46 miles, equal to 93 per cent. of the entire length of the work covered by this department. The total amount of these contracts is $1,815,898.40.

The portions of the aqueduct not yet let include the pipes leading from the Sudbury Dam to the upper end of the aqueduct, together with the head-house and other structures, and two steel siphon pipes, one across the valley of the Sudbury River north of Saxonville and the other across a depression known as Happy Hollow, about a mile east of the Sudbury River.

A contract has already been made for furnishing the pipes which are to lead from the Sudbury Dam to the head-house. All contracts for the aqueduct and reservoir provide that the work shall be completed on or before August 1, 1903.

Description of Works.

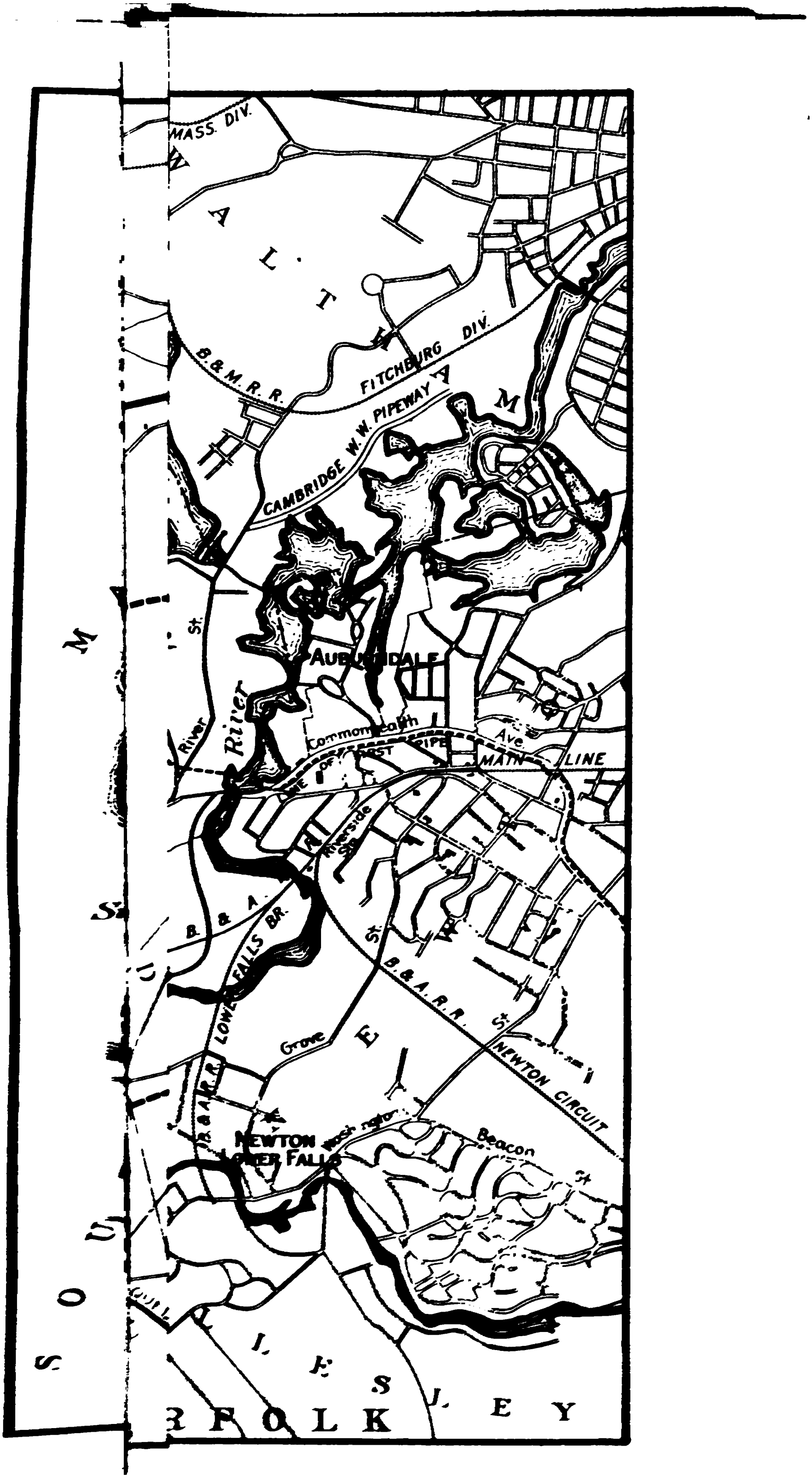
The course of the new aqueduct, starting at the Sudbury Dam and running easterly through the towns of Southborough, Framingham, Wayland and Weston, is shown on an accompanying map.

The aqueduct is designed so as to have in all parts a capacity for conveying 300,000,000 gallons of water per day; but, owing to the conformation of the country through which it passes, it varies in size and method of construction in different parts.

From the Sudbury Dam to the New York, New Haven & Hartford Railroad, near the Nobscot station, it was feasible to obtain a fall in the masonry aqueduct of 4 feet in 5,000, and for the remainder of the distance, down to the reservoir, a fall of only 1 foot in 5,000.

For the safe operation of the aqueduct it is necessary to have an equalizing reservoir near its lower end. A site suitable for such a reservoir was found in a valley rather more than a mile above the terminal chamber. The reservoir and an open channel leading to it have a total length of about a mile, and for this distance the masonry aqueduct will be omitted, the water flowing from the aqueduct into the upper end of the open channel, and, after passing through the open channel and reservoir, entering the lower section of the aqueduct.

The following table gives the length of the different portions of the aqueduct, beginning at the Sudbury Dam: —


MASS. DIV.
W A L T H A M
B.&M.R.R. FITCHBURG DIV.
CAMBRIDGE W.W. PIPEWAY
M
AUBURNDALE
River St
River
Commonwealth Ave
LINE OF FIRST PIPE
MAIN LINE
Riverside Sta
B. & A.
LOWER FALLS BR.
B.&A.R.R.
NEWTON CIRCUIT
St
Grove
E
W
NEWTON LOWER FALLS
Washington
Beacon St
M S D
S O U
RFOLK
W E L L E S L E Y

PORTION OF WORK.	Feet.	Miles.
Three 5-foot cast-iron pipes from Sudbury Dam to head-house,	479	.09
Head-house and 10-foot aqueduct in open trench, . . .	195	.04
10-foot aqueduct in earth tunnel, ...	704	.13
10-foot aqueduct in open trench, ...	2,826	.53
10-foot aqueduct in rock tunnel, ...	3,015	.57
10-foot aqueduct in open trench, ...	4,075	.77
10-foot aqueduct in rock tunnel, ...	2,160	.41
10 foot aqueduct in open trench, ...	5,170	.98
Special section under New York, New Haven & Hartford Railroad, ...	130	.03
13-foot 2-inch aqueduct in open trench and siphon chamber, .	9,690	1.83
One 7½-foot riveted steel siphon pipe across Sudbury River, .	3,603	.68
13-foot 2-inch aqueduct in open trench and siphon chambers, .	3,465	.66
One 7½-foot riveted steel siphon pipe across Happy Hollow, .	1,123	.21
Siphon chamber and 13-foot 2-inch aqueduct in open trench, .	16,470	3.12
13-foot 2-inch aqueduct in earth and rock tunnel, . . .	5,686	1.08
13-foot 2-inch aqueduct in open trench and channel chamber,	1,100	.21
Open channel, ...	1,366	.26
Weston Reservoir, ...	4,000	.76
Screen chamber and 13-foot 2-inch aqueduct in open trench, .	1,513	.29
13-foot 2-inch aqueduct in rock tunnel, ...	600	.11
13-foot 2-inch aqueduct in open trench and terminal chamber,	3,612	.68
Total length of line, ...	70,982	13.44

The elevations in feet above Boston city base of the top of the inside of the aqueduct at its beginning and end and at intermediate points where there are changes in grade are as follows: —

LOCATION.	Elevation.
Head-house, ...	225.130
End of 10-foot aqueduct west of special section under New York, New Haven & Hartford Railroad, ...	210.660
Beginning of 13-foot 2-inch aqueduct east of special section under New York, New Haven & Hartford Railroad, ...	210.660
Siphon chamber No. 1, ...	208.723
Siphon chamber No. 2, ...	206.319
Siphon chamber No. 3, ...	205.626
Siphon chamber No. 4, ...	204.739
Channel chamber, ...	200.087
Screen chamber, ...	200.067
Terminal chamber, end of masonry aqueduct, ...	200.067

The top of the aqueduct at the head-house is 34.87 feet below high water in the Sudbury Reservoir. High water in the Weston

Reservoir is at elevation 200, substantially at the level of the top of the aqueduct, 66 feet higher than Chestnut Hill Reservoir and 37 feet higher than Spot Pond. From the terminal chamber the water will flow by gravity through large pipes to the low-service district and to Spot Pond.

Pipes from Sudbury Dam to Head-house.

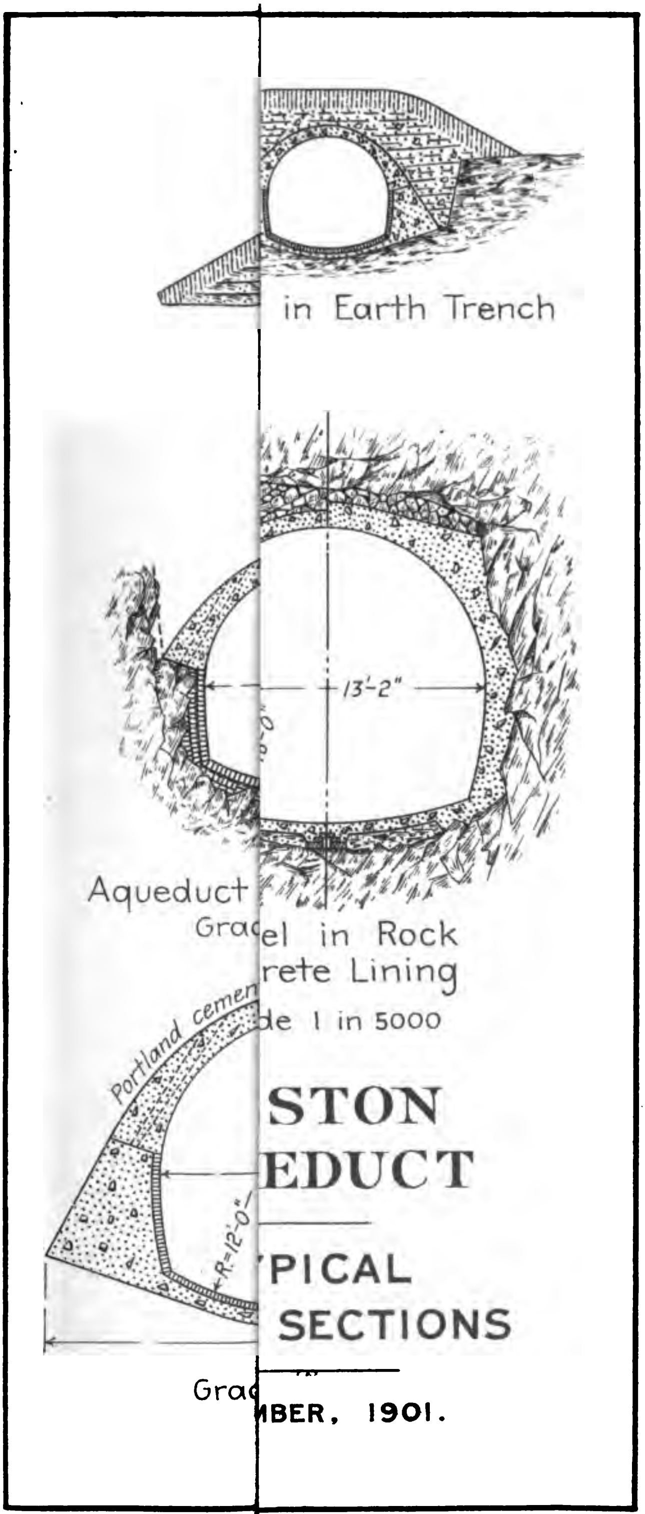
When the Sudbury Dam was constructed, 3 48-inch pipes were laid from the gate-house to a circular basin below the dam. These pipes are to be extended and utilized for supplying water to the new aqueduct. The extensions are to be made with 5-foot cast-iron pipes, two of which will have branches leading from them to discharge water from the Sudbury Reservoir into Framingham Reservoir No. 3. Two 60-inch Venturi meters will be placed on two of the lines leading to the head-house, for measuring the flow of the aqueduct. The head-house will be provided with screens and gaging appliances, and with an overflow so designed that the aqueduct cannot be overcharged through accident or negligence in regulating the flow from the gate-house at the dam.

Masonry Aqueduct and Tunnels.

The aqueduct, both in open trench and in tunnel, will be of the same shape and type of construction as the Wachusett Aqueduct, described in the second annual report of the Metropolitan Water Board, for the year 1896, except that Portland cement concrete will be substituted for brickwork in the lining of the tunnels. An accompanying plan shows typical sections of the aqueduct. Where the aqueduct is built in open trench or on embankments, the bottom and side walls are constructed of natural cement concrete, lined with one course of brick masonry, and the arch of Portland cement concrete.

In the Wachusett Aqueduct it was found that by the contraction of the concrete, through temperature changes or otherwise, the sections of arch built at different times would separate where the new work joined the old, making a minute transverse crack. As the same result is expected in the Weston Aqueduct, a new device, called a water-stop, has been adopted, to reduce the possible leakage through such cracks.

In building the concrete, a straight groove is left in both the old



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and new work, in the position shown upon the sections, forming a slot which extends from the top of the side walls to a point nearly at the level of the top of the inside of the aqueduct. In each of these slots is placed a strip of sheet lead extending from the top to the bottom, and bent in such a way that the lead will act as an expansion joint, and not be torn apart if a shrinkage crack is produced. The space around the lead is carefully filled with Portland cement mortar, but before filling with the mortar a piece of sheet iron is inserted in the fold of the lead, on a line with the junction of the sections of arch, so that if a shrinkage crack occurs it will extend through the mortar filling.

The arch centres, as in previous similar construction, have been covered with galvanized iron, to secure a smooth interior surface, and lubricated each time before laying the concrete, to prevent the concrete from adhering to the centres. Oil has been used as a lubricant, also soft soap, which has the advantage over oil of being easily washed off before applying a plastering, which is applied to all parts of the arch of the aqueduct in open trench. This plastering is of a thickness and finish equal to a plasterer's finished coat, and is composed of neat Portland cement, thoroughly trowelled in, and before the final set smoothed with a wet soft bristle brush, applied lengthwise of the aqueduct.

Siphons and Siphon Chambers.

At the valley of the Sudbury River the ground falls about 75 feet below the grade of the aqueduct, and at Happy Hollow about 50 feet below this grade. It is the design to lay ultimately across these valleys three 7½-foot riveted steel pipes, but only one is to be laid at the present time.

Where the pipe crosses the Sudbury River it will be given the form of an arch, between abutments 80 feet apart, so that it will support itself. Blow-off pipes will be provided for draining the siphons. Two will be placed on each pipe at the river, where large quantities of water can be discharged, and one at the bottom of the depression at Happy Hollow. One pipe will convey more than half as much water as the three, because when the aqueduct is running to only half its capacity it will be about half full at the down-stream end of the lower pipe and can be filled full at the upper end, giving more than the normal fall through the pipes.

The siphon chambers, which make the junction between the aqueduct and the siphon pipes, have been designed so that there will be the least possible disturbance of the flow in passing from one to the other. Some very large castings of special shape are to be built into masonry, to make the junction with the steel pipes. Grooves for gates are provided, so that when there is more than one pipe, any one can be shut off for examination and repairs.

Weston Reservoir and Open Channel.

The necessity for an equalizing reservoir arises from the fact that the pipes of the distributing system will convey more water in the daytime, when there is the larger use of water in the Metropolitan District, than at night, when less water is used, and consequently some of the water has to flow the much greater distance to Spot Pond. The site obtained for this reservoir is a satisfactory one, as there is a natural valley which can readily be dammed by an embankment of earth, with a concrete core wall founded upon solid rock. At the site of the dam there is a low, rocky ridge running most of the way across the valley, which by its presence makes the dam less costly than it otherwise would be.

The maximum depth of water at the dam is about 28 feet. The natural reservoir which would be formed by the dam without excavating above it would not be large enough to meet the requirements, and the reservoir is to be made much larger by excavating flat land which is nearly at the level of high water in the reservoir. All soil and organic matter are to be removed from the deeper portions of the reservoir, and where the depth of water obtained by the removal of the soil is less than 11 feet, the earth is to be excavated so as to obtain this depth.

The shores of the reservoir will be protected by riprap, or coarse gravel beaches, as conditions may require.

The open channel is practically an extension of the reservoir at its upper end, and the water will stand in it at the same level as in the reservoir. It will have a bottom width of 10 feet, with gravel sides sloping at the rate of 3 horizontal to 1 vertical. Above a berm 1 foot above the water the sides will be covered with loam and grassed. A stone arch bridge is to carry Ash Street over the open channel at the extreme upper end of the reservoir.

The open channel has a length of 1,366 feet and the reservoir a length of 4,000 feet, making a total length of 5,366 feet where the masonry aqueduct is omitted. The reservoir and open channel together have an area of water surface of 66.6 acres, which is a little more than half the area of Chestnut Hill Reservoir, and contain about 20,000,000 gallons per foot of depth. Where the masonry aqueduct terminates at the head of the open channel, a structure known as the channel chamber is to be built, which will contain grooves in which stop-planks may be placed if it is desired to empty the aqueduct without lowering the reservoir. Where the water flows from the reservoir into the lower section of the aqueduct a screen-chamber is to be built. In order to protect the waters of the reservoir and open channel from pollution, a system of drainage has been devised which will prevent the entrance of any water from local sources.

Especial attention has been given to the design of the outlines of the reservoir and to the disposition of waste material, so as to produce satisfactory landscape effects. These matters have been carefully studied by Olmsted Brothers, Landscape Architects, and they have given advice and furnished plans for the work.

Culverts and Crossings.

Thirty-nine culverts are required to provide for streams crossing the aqueduct, and additional culverts are provided through roads and private crossings where necessary.

The aqueduct, where not in tunnel, crosses 15 public highways, 4 of which are to be restored to their original grade, and the remaining 11 will be raised to pass over the aqueduct. In addition to the highways, there are private crossings provided over the aqueduct at 49 places.

CONTRACTS, WESTON AQUEDUCT.

Sections 2, 3, 6 and 12. — Masonry Aqueduct and Tunnels.

Contractor, Shanahan, Casparis & Co.; date of contracts, May 9, 1901; amount of contracts, $582,727.50; length of aqueduct, 24,975 feet, including 5,879 linear feet of tunnels. The aqueduct, on sections 2 and 3, has a width of 10 feet, and on sections 6 and 12 a width of 13 feet 2 inches.

The contractors were early on the ground, but some difficulty was experienced in securing labor and more or less delay was suffered in the erection of camps and the delivery of tools and materials, and the work of organization progressed slowly.

The headquarters and main camps for the accommodation of men and supplies are located principally on private land, in a secluded spot on the high ground over tunnel No. 2, about 2¼ miles from Framingham village and ⅓ mile from the nearest dwelling. Other camps are located about 1 mile north of Saxonville and 1½ miles southeasterly from Wayland.

The contractors have devoted almost their entire efforts to the construction of aqueduct in open trench, and the tunnel work, pending the erection of the power plant, was deferred until the close of the mild weather season. Progress in the open trench work on sections 2 and 3 has been generally satisfactory, slightly more than the work required having been completed this year.

The contractors were dilatory in perfecting their organization for Section 6, and excavation was not begun until June 10. The masonry construction was started August 22, and the amount of completed work at the close of the season was one-third less than the contract requirements, although the rate of progress for the actual time employed was satisfactory.

Progress on Section 12 was far from satisfactory until late in the season, organization and equipment suffering much delay. Masonry work was begun July 24, but little progress was made until the latter part of September; from that time until the close of the season a much better rate was maintained. The value of the work done on this section on November 15 was 23 per cent. of the amount of the contract, while the contract requirement was 30 per cent.

For about 700 feet on Section 3 and 300 feet on Section 6 the aqueduct crosses a swamp formation of moderate depth below the base of the aqueduct. The peat or mud deposit has been entirely removed down to compact earth, and filling for foundation has been prepared of selected material deposited in 3-inch layers, watered and rolled with heavy grooved rollers. With these exceptions the aqueduct under these contracts is being constructed partly or wholly in excavation. Considerable water was encountered in the open trench excavation between tunnels Nos. 2 and 3 and at the easterly end of Section 12. A small wooden box drain at the bottom of the excavation has usually sufficed to keep the water below the concrete during construction, although in a few instances, where a greater quantity of water was encountered, a light platform of fluted boards was laid in connection with the central drain.

The excavations have furnished considerable sand and gravel for use in the masonry on sections 2, 3 and 12, but the contractor has been obliged to obtain much of the sand for sections 2 and 3 and all of the sand used on Section 6 from private lands. It has also been necessary to operate stone crushers, with elevators, screens, bins, etc., on each of the sections included in these contracts, to furnish additional stone for concrete work.

For tunnel work, a central power plant, to furnish compressed air for operating the drills, pumps and other machinery in connection with tunnels Nos. 2 and 3, has been erected near Baiting Brook, a point nearly midway between the most distant portals of those tunnels. The compressed air is conveyed to the working points through wrought-iron pipes laid on the surface of the ground; the main air pipe, consisting of 4,200 feet of 5-inch and 5,100 feet of 4-inch pipe, is now laid and in operation.

The contractors placed their order for the machinery needed for this plant almost immediately after the execution of their contracts; but even this promptness, together with a guarantee from the manufacturer that one compressor would be running in 70 days and the whole plant completed within 100 days, did not avail in avoiding a long delay in the delivery; and it was not until December 2 that the first compressor was put in operation, and it was December 28 before all the machinery was in readiness to use. The main installation consists of two cross-compound air compressors of 150 horse-power each, and two horizontal tubular high-pressure boilers of 300 horse-power each.

Tunnel No. 1 is in a compact clayey material, and at present the lining of brick masonry is carried along with the excavation. Tunnels Nos. 2 and 3 are expected to be wholly through ledge, and the lining, which in these cases will be concrete masonry, will be deferred until the excavation is completed, or at least well advanced.

The following tabulation shows the progress made in these tunnels at the end of the year: —

Progress in Tunnels Nos. 1, 2 and 3, December 31, 1901.

TUNNEL.	Length (Feet).	Began Work.	EXCAVATION.		Total.
			East Portal (Linear Feet).	West Portal (Linear Feet).	
No. 1, . . .	704	November 20, 1901,	23	–	23
No. 2, . . .	3,015	December 2, 1901,	82	–	82
No. 3, . . .	2,160	December 2, 1901,	–	83	83

The maximum force employed on these sections was 585 men and 83 horses, for the week ending August 31.

Section 4. — Masonry Aqueduct.

Contractor, Patrick McGovern; date of contract, May 8, 1901; amount of contract, $[illegible]; length of aqueduct, [illegible] feet; width, 10 feet.

Work was begun early under this contract, and most excellent progress has been made during the season. The value of the work completed November 15 was 72 per cent. of the amount of the contract, while the contract requirement was 50 per cent. The aqueduct is entirely in open trench. For about 1,500 feet east of Edgell Street the excavation was in light sandy material, affording excellent opportunity for rapid progress; west of Edgell Street the excavation has been more difficult, considerable ledge having been encountered. At several points gravel was developed, affording material for concrete masonry, but a stone crusher to furnish additional material was found necessary early in the season. East of Edgell Street the foundations were below the level of ground water for some distance, and a light platform of boards with central drain was employed to keep the concrete dry until hardened.

The maximum force employed on this section was 120 men and 18 horses, for the week ending August 10.

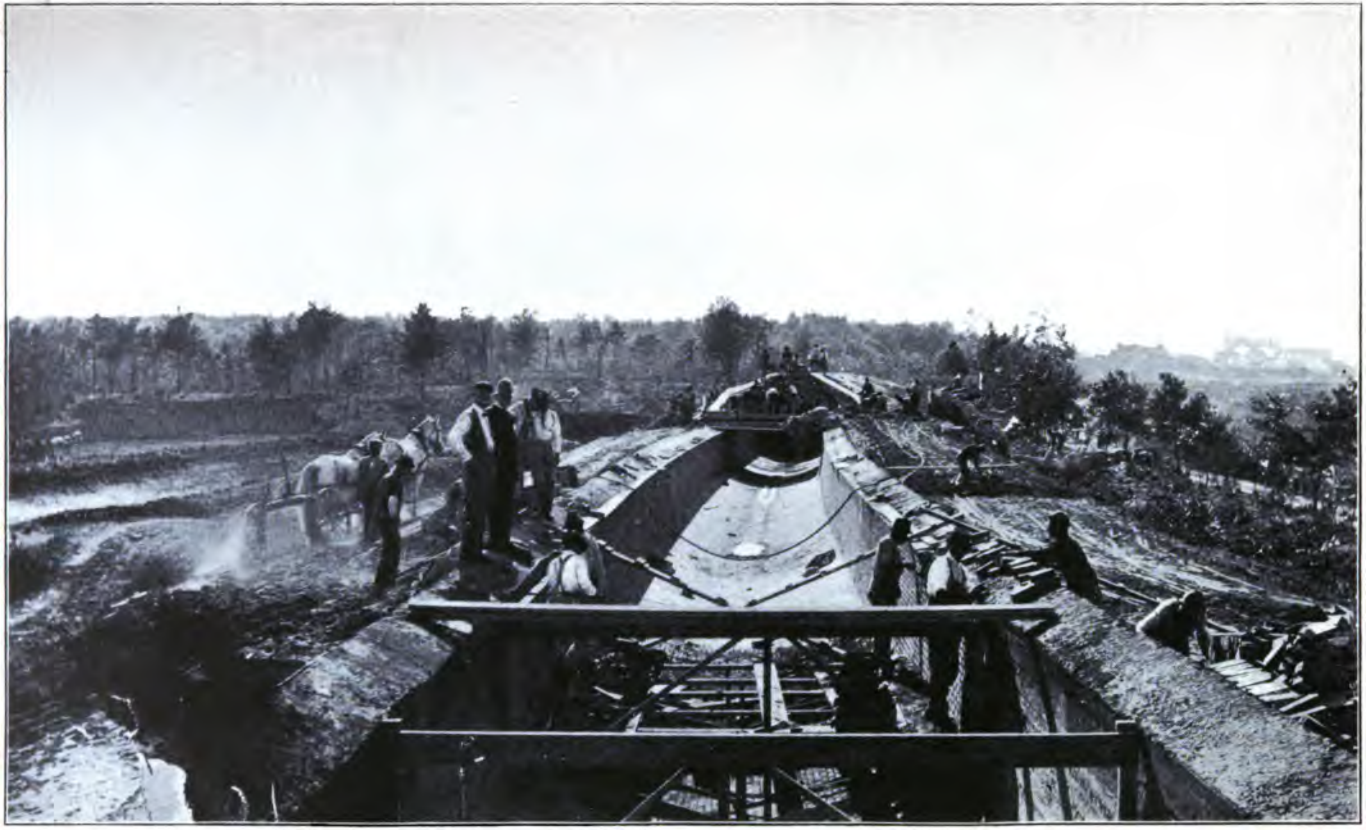
Section 5. — Masonry Aqueduct.

Contractor, Bruno, Salomone & Petitti; date of contract, May 8, 1901; amount of contract, $137,596.50; length of aqueduct, 5,295 feet, including crossing under the tracks of the New York, New Haven & Hartford Railroad at Cochituate station; width of aqueduct, 13 feet 2 inches.

These contractors commenced operations very promptly, and prosecuted their work vigorously during the working season.

The aqueduct is principally in open trench, but at one place, for a length of 1,400 feet, the original ground surface is from 1 to 6 feet below the bottom of the masonry. For that space the foundation was prepared by removing the soil and building an embankment in 3-inch layers, using water and heavy grooved rollers to consolidate the material, and after completion the embankment was flooded twice before laying the masonry. The material used for filling was a very fine sand, with coarse gravel at the sides of the embankment.

The masonry construction could not well be begun until a section of this embankment had been completed, and consequently it was not started until July 29; but excellent progress was maintained



WESTON AQUEDUCT -- SECTION ON EMBANKMENT, DURING CONSTRUCTION.

until it was necessary to stop on account of freezing weather. It was deemed desirable that this embankment, once begun, should be made and the aqueduct completed before freezing weather, and by concentrating their forces the contractors were successful in accomplishing this result.

The value of the work completed November 15 was 36 per cent. of the amount of the contract, while the contract requirement was 30 per cent.

A stone-crushing plant was in nearly constant operation, to furnish the balance of the stone not obtainable by screening the gravel excavated from the trench.

The maximum force employed on this section was 132 men and 41 horses, for the week ending September 28.

Section 13. — Masonry Aqueduct and Tunnel.

Contractor, Michael H. Keefe; date of contract, May 20, 1901; amount of contract, $346,290; length of aqueduct, 7,300 feet, of which 5,686 feet are tunnel; width of aqueduct, 13 feet 2 inches. This contract was assigned to the Columbus Construction Company October 12.

Proposals for the construction of this section of the aqueduct were first received April 30. The lowest bid amounted to $293,083.25 and the next bid to $395,390. The contract was awarded to the lowest bidder, but he claimed that he had made a mistake in his calculations, and declined to sign the contract. The Board thereupon decided to reject all bids and to receive further proposals on May 14. The lowest of these proposals, amounting to $346,290, was accepted.

The contractor started upon the work very promptly, and, notwithstanding the scarcity of labor and the delays arising from slow delivery of machinery and supplies, the excavation of the west portal had progressed sufficiently to begin a tunnel heading on June 24. The boilers and engine for the air compressor were received the latter part of June, but were not ready for operation until August 16. The excavation of the open cut at the east portal of the tunnel progressed slowly, and tunnelling was not commenced at that end until August 26.

During the summer and early autumn the progress upon the tunnel, which needed to be large to meet the contract requirements, was quite unsatisfactory; and it soon became apparent that more plant and resources than the contractor appeared to have at his disposal would be necessary in order to complete the contract within the stipulated time. An arrangement was therefore perfected for obtaining additional capital by the organization of a company to carry on the work; and by the consent of all parties the contract was assigned on October 12 to the Columbus Construction Company, of which S. Casparis is president, Joseph A. Flynn secretary and treasurer, and Mr. Keefe one of the stockholders.

Immediate steps were taken by the Columbus Construction Company to increase the working facilities. Additional and improved boarding houses for the laborers, as well as engine houses, stables, shops and cement sheds, were built. A second compressor engine and another boiler were ordered, and were put in operation November 2. An engine and dynamo were also installed to furnish electricity for lighting and motive power in tunnel. The working force was increased as rapidly as boarding accommodations could be provided, and throughout the month of December a full force of about 140 men, divided into day and night shifts, was employed.

It necessarily required some weeks to accomplish this preliminary work, and until it was completed the greatest possible rate of progress in the tunnel excavation could not be expected; but afterwards there was a continued gain in the rate of progress, although up to the end of the year the desired rate had not been fully attained, largely on account of the unfavorable conditions of the ground at the west end of the tunnel. At this end of the tunnel, for the whole 530 feet excavated from the portal to the point reached at the end of the year, the lower part of the tunnel has been in rock and the upper part in a compact clayey material, which is so hard as to require drilling and blasting, but wet enough to render it unstable, and to require continuous and systematic timbering for its support. In this material the progress has necessarily been slower than in the solid rock, such as is encountered at the east end of the tunnel. There the formation is a massive, coarse-grained granite, which is hard to drill, but blasts well and does not require support.

The total length of the tunnel is 5,686 feet, and at the end of the year the total amount excavated was 1,001 feet, consisting of 530 feet at the west end and 471 feet at the east end, which was 559 feet less than the requirements at this time.

The power station is located at the west portal of the tunnel, and contains two Ingersoll-Sergeant straight-line 18-inch by 18¼-inch by 24-inch air compressors; two Westinghouse standard engines of 60 horse-power and 20 horse-power, for driving electric generators; and one Thomson-Houston 500-volt, 70-kilowatt direct-current generator, to furnish electricity for lighting and for operating 4 ½-ton electric locomotives in each end of the tunnel. Additional machinery in use outside of the central station includes 2 double-cylinder double-drum hoisting engines, to operate the inclines by which material is removed from the tunnel; 2 duplex pumps and 2 pulsometers, to drain water from the tunnel; 11 machine drills, and 1 6-ton saddle tank locomotive for hauling material from the east portal to the waste dump, about 2,000 feet distant. As soon as the General Electric Company can deliver them, it is proposed to substitute two 4½-ton electric locomotives for the horses now used for hauling cars underground.

None of the concrete masonry, which it is anticipated will be used almost exclusively for lining in this tunnel, had been built before the end of the year; but preparations are under way for an early start on this lining, as, in order to finish the whole work on time, it will be necessary to have the masonry and excavation proceed simultaneously. The brick arched concrete culvert under Wellesley Street has been completed, except the masonry head walls.

Of the excavation from open trench beyond the ends of the tunnel, about one-quarter of the total amount has been made. At the east end of the section, where a deep trench is required, the material was removed with a steam shovel.

The maximum force employed on this section was 147 men and 5 horses, for the week ending December 21.

Sections 8 and 10, 11 and 15. — Masonry Aqueduct and Tunnel.

Contractors, Winston & Co.; date of contracts, August 28, 1901; amount of contracts, $466,419; length of aqueduct, 18,715 feet, inclusive of 3 siphon chambers on sections 8 and 10, and the screen and terminal chambers and 600 feet of tunnel on Section 15; width of aqueduct, 13 feet 2 inches.

These contracts were awarded so late in the season that it was not expected that very much work would be done, except on Section 15, where the excavation of the tunnel and some rock cuts could be continued during the winter.

As all of these sections were let to one contractor, it was thought that he might perfect his organization for masonry construction without building masonry on more than one section; and the contractor chose the easterly portion of Section 8 as a favorable place to begin the building of masonry. He lost no time in commencing operations, and pushed his work with most commendable energy.

On Section 8 excavation was commenced September 9, the first masonry laid October 10, and 500 linear feet of aqueduct completed before the close of the season. This, together with 800 feet of trench excavation on this section and other preliminary work done, may be said to represent about double the contract requirements for sections 8 and 10, which are included in one contract.

An abundance of excellent sand and gravel was found in the excavations on Section 8, and a rotary power screen, with conveyor, bins, etc., has been operated to separate the sand and gravel, resulting in much economy over hand methods.

On sections 10 and 11 nothing has been done further than clearing the strip taken for the aqueduct, removing the wood and burning the brush.

On Section 15 the necessity of grading roads to get access to the work, before camps could be built, and the further need of obtaining a water supply before much grading could be done, tended to delay the commencement of actual work until September 28. Since that date the clearing, grubbing and excavating have progressed steadily, although rather slowly; and at the end of the year about half the amount of work required by the contract had been completed. The actual progress, however, should be regarded as greater than indicated by the above statement, as a large part of the preliminary work of organization, building camps and installation of machinery had been accomplished.

To furnish power for running drills in the tunnel and open trench and for hoisting and pumping, a plant consisting of 3 70-horse-power boilers and a Rand Imperial air compressor of 120 horse-power has been provided, and was put in operation November 25. Other machinery on the ground, but not yet all in use, includes travelling derrick and hoisting engine complete, 7 machine drills, 1 No. 5 Gates crusher with engine and elevator, pumps, cars, rails, etc.

The maximum force employed on these sections was 118 men and 32 horses, for the week ending October 26.

Section 14. — Open Channel. — Sections 1 and 2, Weston Reservoir.

Contractor, Nawn & Brock; date of contracts, November 26, 1901; amount of contracts, $206,370; length of three sections, 5,050 feet, including about 1,400 feet of open channel, 66.6 acres of reservoir and channel, and an earth dam 900 feet long, with concrete core wall.

These contracts were let in the autumn, before the ground was covered with snow, so that the contractor might arrange for the erection of buildings, the delivery of machinery and the organization of forces during the winter, and make an early and vigorous beginning as soon as the frost leaves the ground. No work has been done on the ground under these contracts.

In order to provide a main drainage channel, so that the reservoir would be well drained for the commencement of work in the spring, and to get it in condition at the time of the letting so that contractors might have access to all parts of the reservoir and see the nature of the materials, a considerable amount of work was done by a day-labor force in the summer and autumn, in digging the main channel and lateral ditches, in excavating test pits, in laying bare a portion of the rock at the site of the dam and in cutting the brush from the site of the reservoir.

PROGRESS OF WORK AND MATERIALS USED.

During the season the total length of aqueduct built in open trench equalled 11,222 feet, or 23 per cent. of the total length. The following statement gives the length of aqueduct built and to be built in open trench on each section: —

SECTION.	Built.	To be Built.	SECTION.	Built.	To be Built.
Section 2, ...	2,368	2,368	Section 10, . .	–	2,925
Section 3, ...	1,417	1,923	Section 11, . .	–	6,600
Section 4, ...	3,271	884	Section 12, . .	1,264	5,236
Section 5, ...	1,567	3,728	Section 13, . .	–	1,614
Section 6, ...	841	3,679	Section 15, . .	–	5,125
Section 8, ...	494	2,971			

The following materials have been used during the year: —

Natural cement (barrels), ...	26,658
Portland cement (barrels), ...	13,810
Bricks, ...	1,601,000

ENGINEERING.

The time of the engineering force has been devoted wholly to the completion of the preliminary surveys, preparation of plans and other matters pertaining to the several contracts which have been awarded during the year, and later to the direction and supervision of the work under construction.

Extraordinary care was taken in the surveys and studies for the location of the aqueduct and other structures, to insure the best and most economical adjustment of the same to existing natural conditions; and during the early spring considerable attention was given to a final revision of the alignment of the aqueduct and open channel and margins of the Weston Reservoir. To aid in these studies, further information was gained relative to the character of materials to be moved, by digging 74 test pits, amounting to a total of 380 linear feet, and by 10 wash drill borings and 664 rod soundings, aggregating, respectively, 144 and 6,015 linear feet.

Considerable time and study have been given to the location of the steel siphon pipes to cross the Sudbury valley and Happy Hollow.

The nature and area of the watersheds and the position and sizes of the culverts to carry the drainage across the aqueduct were determined, and 43 topographic and 46 detail culvert plans have been furnished in this connection. The required changes in grade for the various highway crossings in Framingham and Wayland were carefully studied, and plans for the modification of 13 roads have been prepared.

Plans for the highway crossings in Framingham have been accepted by the selectmen; those for Wayland have not yet been acted upon.

The work in connection with the matter of lands required for the aqueduct and reservoir has taken much time. Surveys were made of all estates crossed by the aqueduct, as well as many adjoining tracts, and land-taking plans have been drawn to cover the whole work. These consist of 20 large sheets, showing dimensions, areas, etc., of the 153 parcels of land taken for aqueduct and reservoir purposes; in addition to these, 3 long roll plans, showing the land surveys and takings on a scale of 100 feet to 1 inch, have been prepared for office records.

Estimates of quantities and cost were furnished as required, to serve as a basis in letting contracts for the 14 sections for which proposals were received.

Cement testing was an important branch of the work in this department, and received careful attention. A room was suitably equipped for this work, and the testing begun on June 3, when the first carload of cement was received. One cement tester was employed until June 27, when it was necessary to give him an assistant. A third man has been employed collecting samples and noting deliveries of cement and bricks. All the cement received thus far has been packed in jute or cotton bags, ranging from two to four bags to the barrel, according to the brand of cement. A system of marking, consisting of attaching to each bag a tag giving the car number, has been followed. This serves to identify the cement to the inspector on the work, who is furnished with a list of accepted carloads.

During the year 301 carloads of cement, containing 45,365 barrels, were received and tested, and 14,000 briquettes were made for the purposes of the tests required. Thus far only four kinds of cement have been used in this masonry, viz., Hoffman, Union, Atlas and Giant. A summary of the cement tests is given in Appendix No. 2.

The bricks used in the aqueduct have come principally from the Granite State Company of Epping, N. H., but a few were from the Star Brick Company of the same place, and another small lot from the Cambridge yards of the New England Brick Company. Something over 2,000,000 bricks have been received during the year.

DISTRIBUTION DEPARTMENT.

DEXTER BRACKETT, *Department Engineer.*

The work of this department comprises the construction, maintenance and operation of the pipes, distributing reservoirs, pumping stations and all other works in the Metropolitan Water District, with the exception of Chestnut Hill Reservoir and the grounds about it, and the Sudbury and Cochituate aqueducts.

During the past year the work of the department has been under the direct charge of the following assistants: —

William E. Foss, division engineer, has had charge of the engineering work connected with the construction of the Bear Hill Resertown in Stoneham and the laying of pipe lines for supplying that town with water; also of studies and investigations relating to the injury of the pipes by electrolysis, and of surveys and investigations for pipe lines leading from the terminus of the new Weston Aqueduct.

John L. Howard, division engineer, has been in charge of the engineering work connected with construction at the Chestnut Hill and Spot Pond pumping stations; also of making surveys, plans and estimates for pipe lines leading from the terminus of the new Weston Aqueduct into the Metropolitan Water District.

Caleb M. Saville, division engineer, has had charge of the engineering work connected with the Forbes Hill Reservoir and tower in Quincy, and the tunnel for pipes under the channel of the Mystic River between Charlestown and Chelsea.

Alfred O. Doane, division engineer, has had charge of the engineering work connected with the maintenance and operation of the several pumping stations and pipe lines, the installation of gages for recording the elevation of the water in the reservoirs and the pressure in the pipes; also of the records of amounts of water pumped and consumed.

John W. Lynch, engineer of pumping stations, has had direct charge of the high and low service pumping stations at Chestnut Hill, as well as the general supervision of the mechanical work at the other pumping stations.

George E. Wilde, assistant superintendent, has continued in charge of the maintenance and operation of pipe lines, reservoirs and other works in the Distribution Department, with the exception of the pumping stations; and has also had charge of the minor works of construction which have been done by day-labor forces.

The engineering force, including inspectors, numbered 34 at the beginning of the year, but has gradually diminished, and at the close of the year numbered 23.

The construction work of the year has included the completion of the buildings and machinery at the new pumping stations at Chestnut Hill and Spot Pond. The reservoir on Forbes Hill has been finished and placed in service, and the masonry tower around the standpipe near the reservoir is nearly completed. Pipes for furnishing a supply of water from the Metropolitan Works to the town of Stoneham have been laid and are now in use. The Bear Hill

Reservoir, which will be used for furnishing water to Stoneham under a greater pressure than at present, was nearly finished when work was suspended for the season.

PIPE LAYING.

The only important extension of the pipe system was made for the purpose of furnishing a supply of water to the town of Stoneham, which entered the Metropolitan Water District on May 23, 1901. A 24-inch line, 5,831 feet in length, was laid from the Spot Pond pumping station around the northeasterly end of Spot Pond to the junction of Main and South streets; from this point a 20-inch line, 1,619 feet in length, extends through the Middlesex Fells Reservation to the Bear Hill Reservoir; and another 20-inch line, 4,766 feet in length, through Main Street to Stoneham Square, where it connects with the main pipe of the town. A Venturi meter was set in the pipe line near the pumping station, for use in measuring the quantity of water used in Stoneham.

A contract for laying these pipes was made with the C. H. Eglee Company of Boston, on June 22, and the work was commenced June 25. The portion of the line between the pumping station and the town of Stoneham was completed and placed in service on October 21, but the pipes connecting with the Bear Hill Reservoir were not all laid until December 4.

In connection with this pipe laying a five-conductor lead-covered cable was laid between the pumping station at Spot Pond and the Bear Hill Reservoir, for use in connection with a gage for indicating and recording at the pumping station the elevation of the water at the reservoir, and also for telephone service.

The cost of this work, exclusive of engineering, to December 31, 1901, was $48,442.75.

BEAR HILL RESERVOIR.

This reservoir, which will contain 2,000,000 gallons of water with a full reservoir level 300 feet above Boston city base, is being constructed for the purpose of furnishing a greater pressure in the town of Stoneham than would be furnished by the Fells Reservoir, which is 29 feet lower. It is located in the Middlesex Fells Reservation, near the summit of Bear Hill, and is formed by building two dams [illegible] the [illegible] the [illegible], and excavating all the earth [illegible] area.

A contract for building the reservoir was made with the [illegible] Company of Boston, on [illegible]. Work was begun in July [illegible], and at the close of the season the [illegible] masonry dams were nearly finished, the construction of the [illegible] commenced, and most of the earth had been removed from the interior of the basin. The reservoir has been filled with water to within [illegible] feet of high-water mark, for the purpose of protecting the masonry.

The cost of the work, exclusive of engineering, to December [illegible], 19[illegible], was $[illegible].

Forbes Hill Reservoir and [illegible] Tower.

The contract for building this reservoir was made with Beckwith & Quackenbush of Albany, N. Y., on July [illegible], and when work was suspended at the close of the year [illegible], the masonry gate-chamber of the reservoir was finished and the earth embankments were nearly ready for the concrete lining. During the winter the reservoir was kept full of water in order to protect the embankments from freezing. In April, [illegible], the water was drawn off, and the contractors resumed work on May [illegible]. The work of placing the concrete lining was commenced June 1, and completed September 18. Water was admitted to the reservoir on September 23, and on September 27 it was filled to within 2 feet of high-water mark. The laying of the granolithic walks and the surfacing and seeding of the embankments were not finished until early in November.

The reservoir is in the form of a rectangle, 280 feet long by 100 feet wide at the bottom, and [illegible] feet long and 159½ feet wide at the high-water line. The embankment is 15 feet wide at the top, with an inner slope of 1.75 horizontal to 1 vertical, and an outer slope of 2 horizontal to 1 vertical. The embankments are composed of clayey hardpan, excavated from the interior of the reservoir. This material was placed in 4-inch layers and thoroughly rolled with grooved rollers. The bottom and sides of the reservoir are covered with concrete to a point 2 feet above high-water mark. This concrete lining was put on in two layers, a lower layer of natural cement concrete and an upper layer of Portland cement concrete, separated by a plastering of Portland cement mortar about half an inch in thickness. The plastering also was placed in two layers, the bottom layer composed of 1 part of cement and 2 parts of sand, the upper layer of neat cement, which was rubbed to a hard, smooth surface, in order to make it as impervious as possible. The lower layer of concrete is 4 inches thick on the bottom of the reservoir and 6 inches thick on the slopes. The upper layer is 4 inches thick on the bottom and 5 inches thick on the slopes up to elevation 185, above which it gradually increases to a thickness of 2 feet at the top, which is at elevation 194. The upper layer of concrete on both bottom and slopes is laid in blocks, about 10 feet square, and given a smooth finish. A granolithic walk 6 feet wide extends around the reservoir on the top of the embankment, access to which is obtained by granite steps on either side of the gate-chamber.

The gate-chamber is constructed entirely below the level of the top of the embankment. It has walls of Portland cement concrete, and contains two chambers. One of these chambers is 11 feet by 3 feet, and contains screens, a 30-inch sluice valve and a 12-inch drain valve. The other chamber, from which water is excluded, is 11 feet by 9 feet 6 inches, and contains valves for controlling the flow of water to and from the reservoir. A wire fence 5 feet high and about 2,035 feet long has been built around the reservoir, on the line dividing the water works property from adjoining estates. When filled to high-water level, the elevation of the reservoir is 192 feet above Boston city base, the depth of water is 17 feet, area of water surface 1.23 acres, and the capacity is 5,120,000 gallons.

The cost of the reservoir, exclusive of engineering, to December 31, 1901, was $36,833.11.

On May 23 a contract was made with James E. McCoy of Boston for the construction of a masonry tower around the steel standpipe which was erected in 1900. The work was commenced on May 27, and it was expected that the tower would be entirely finished before the end of the year; but, on account of delay in receiving cut granite, the masonry is still unfinished, and practically nothing has been done on the iron stairway and roof. The circular wall of granite masonry surrounding the standpipe is now built to a point about 70 feet above the ground and about 7 feet below the top of the finished coping. When completed, the tower will be provided with an observation roof reached by a spiral staircase built between the steel tank and the masonry wall.

The cost of the work to December 31, 1901, exclusive of engineering, was $11,774.05.

[illegible] ENGINES, [illegible] AT CHESTNUT HILL AND NORTHERN [illegible] ENGINES, [illegible] AT SPOT POND.

[illegible] these stations were [illegible] the engine [illegible]

At the Chestnut Hill [illegible] the contractors [illegible] and completed [illegible] Spot Pond station [illegible] finished in [illegible]

At the low-service station at Chestnut Hill a steam winch, furnished by the American Ship Windlass Company of Providence, [illegible] has been placed in the coal shed for use in handling coal [illegible] small [illegible] engine with two [illegible] steam cylinders. At the Spot Pond pumping station a [illegible] electric generator directly connected to a [illegible] engine, and a new switchboard, have been installed at a cost of [illegible].

The buildings and machinery at both of these stations are now completed, and the principal items of cost to December 31, [illegible], exclusive of engineering, are as follows: —

Chestnut Hill Low-service Pumping Station.

Building, including foundations for engines and boilers, steel over-flow tank, sluice gates, [illegible] heating piping and wiring for electric lighting,	[illegible] 65
Engines,	153,556 47
Boilers and fuel economizer,	35,712 40
Electric lighting engine, generator and switchboard,	[illegible] 00
[illegible]	2,812 00
Piping and valves in connection with engines and boilers,	16,043 16
Miscellaneous,	5,894 57
Total,	$419,012 25

Spot Pond Pumping Station.

Building, including foundations for engines and boilers, sluice gates, heating piping and electric lighting,	$125,866 36
Engines,	100,787 88
Boilers and fuel economizer,	25,816 42

Electric lighting engine, generator and switchboard,	$1,235 00
Travelling crane,	2,862 00
Water and steam pipes, valves, etc.,	10,007 15
Miscellaneous,	1,083 43
Total,	$267,658 24

The official tests of the four new engines in the low-service and Spot Pond pumping stations were made April 30 and June 4, and the results of the tests, including a description of the pumping plants, may be found in Appendix No. 4.

MISCELLANEOUS.

A small masonry chamber has been built on the Cochituate Aqueduct, near the high-service pumping station, from which water can be taken through a 48-inch pipe to either the high or low service stations. The substructure of this building was built by the maintenance force. The chamber is 7 feet by 9 feet 6 inches and 13 feet deep, with foundations and walls of Portland cement concrete, and contains grooves for stop-planks or screens, and a sluice gate for controlling the flow of water. The superstructure was built by Norcross Brothers, at a cost of $1,552. It is 10 feet 4 inches square on the outside, with exterior walls of quarry-faced Milford granite, brownstone trimmings and a slated roof. The interior is lined with red pressed brick.

In order to increase the supply into the pump-wells at the high-service station at Chestnut Hill, a connection 36 inches in diameter has been made between the screen-chamber and the pump-well of engine No. 4. The castings and sluice valve for this work were purchased in 1900, but a favorable opportunity for setting the castings and valve did not occur until 1901. The work of cutting through and restoring the walls of the screen-chamber and pump-well and placing the castings and sluice gates was done by the maintenance force, and completed at the end of the year.

For the purpose of indicating and recording at the Chestnut Hill high-service pumping station the elevation of the water in the Waban Hill Reservoir, a Winslow electric gage has been installed, and a 5-conductor lead-covered cable, 7,650 feet in length, laid under ground between the pumping station and the reservoir. To provide facilities for emptying this reservoir, in case of repairs, without injury to private property, 489 feet of 8-inch Akron pipe were laid in Commonwealth Avenue, connecting with the surface drainage system in the avenue, and 150 feet of 8-inch iron drain pipe were lowered in Ward Street.

At Spot Pond the planting of trees and shrubs was completed early in the spring by the maintenance force, under the supervision of Olmsted Brothers, Landscape Architects.

The maintenance force has also laid near Spot Pond 200 feet of 8-inch Akron pipe, for the purpose of draining the cellar of the stable belonging to the Metropolitan Park Department; and 1,900 feet of 3-inch tile drain, for draining the land near the junction of Pond and South streets and in the vicinity of the southern gatehouse.

The boiler room of the Arlington pumping station has been enlarged by building an addition, 9 feet by 15 feet, on the north side of the building, making room for a reserve boiler which was purchased from the city of Chelsea. The boiler is 72 inches in diameter, 9 feet 7 inches long, and contains 350 2-inch tubes, 6 feet 1 inch long. The addition to the building was built and the boiler erected by the maintenance force.

ENGINEERING.

The engineering force has been engaged upon the preparation of plans and contracts, and the superintendence of the construction of the Bear Hill Reservoir and of the pipe lines for supplying the town of Stoneham, the superintendence of the construction of the Forbes Hill Reservoir and masonry tower, the tunnel between Charlestown and Chelsea, and work at the Chestnut Hill and Spot Pond pumping stations. Surveys and investigations have been made of several routes for pipe lines leading from the terminus of the Weston Aqueduct into the Metropolitan District, and detailed plans have been made of two of these routes leading to Chestnut Hill Reservoir and of one route leading to the present 48-inch pipes in the Brighton district. Surveys and plans have also been made of several routes for a pipe line between the present terminus of the 48-inch main near College Hill in Medford and Spot Pond. Estimates have been made of the pipes, special castings and valves required for these lines, and specifications and contracts prepared for furnishing the same. Considerable time was devoted to making the official duty trials of the Holly engines at the Chestnut Hill and Spot Pond stations, and to calculating the results. Investigations relating to the effect of electrolysis on the water pipes in the District have been continued, and a special report made upon the subject. Investigations and reports have also been made upon Spot Pond Brook, upon the value of the property taken at Spot Pond from the cities of Malden, Medford and Melrose, upon alleged damage to private property near Spot Pond by flooding during freshets, upon the use of hand-hose and lawn sprinklers in the Metropolitan District, upon the elevation at which water can be maintained in Mystic Lake, and upon the question of supplying water to the town of Braintree.

OFFICE FORCE.

ALFRED D. FLINN, *Principal Office Assistant*, JOHN N. FERGUSON, *Office Assistant.*

Mr. Flinn has continued in charge of the designing and drafting force. The average number in this force during the year was 10. The most important matters upon which the force has been engaged were the Weston Aqueduct and Reservoir, the Wachusett Dam and the masonry tower to enclose the Forbes Hill standpipe.

Studies for the Weston Aqueduct and Reservoir were in progress in 1900, and were continued during 1901. Designs for the greater part of the work were matured and contract plans and specifications were prepared for the letting of almost all of the aqueduct and the reservoir.

The designing for this aqueduct involved an unusual amount of detail work. On account of the different grades of the upper and the lower portions, the aqueduct is of different dimensions. Earth and rock tunnels and a depression of the aqueduct under the New York, New Haven & Hartford Railroad at the Nobscot station required special designs. There were also 42 culverts and about 14 other structures, the principal of which are the outlet chamber near the Sudbury Dam, the head chamber of the aqueduct, 4 siphon chambers, the channel chamber, the screen-chamber and the terminal chamber. Some studies relating to the superstructures for these chambers were made in the drafting office, and foundation plans and other information were prepared for the architects, Messrs. Shepley, Rutan & Coolidge.

The Weston Reservoir and open channel, with the dam and the system of drainage for diverting from the reservoir the water from adjacent lands, required much designing. As already stated, Olmsted Brothers advised with regard to the landscape treatment and the disposal of the material excavated, but much was done upon this work by the designing and drafting force.

A considerable part of the work of preparing the plans for the taking of land for the Weston Aqueduct and Reservoir was done in this office, and a large map was drawn to show the location of the aqueduct.

In connection with the Wachusett Dam, construction drawings were made for a portion of the pool and spillway below the dam, and for the castings and pipes to be built into the dam and the upper and lower gate-chambers. Construction drawings were also begun for these two chambers, and at various times additional study was devoted to the power plant which it is proposed to install in the lower gate-chamber and power house. Sketches and other information relating to the design of the superstructure of these buildings have been furnished to Messrs. Shepley, Rutan & Coolidge.

Contract drawings and specifications for the Forbes Hill tower were prepared on the basis of the sketch for the design furnished by Messrs. Shepley, Rutan & Coolidge in 1900.

The preparation of the card index of the drawings mentioned in the last report was continued by the typewriters from the Library Bureau, and completed by them in February; since then the necessary card writing has been done by the regular employés.

The removal of the offices of the Board and of the Engineering Department from 3 Mt. Vernon Street to 1 Ashburton Place, and the construction of a fire-proof vault in the new office required a general rearrangement of the drawings, which involved much work, in order to get them permanently and conveniently filed; but the results are satisfactory, as the drawings are now properly filed and indexed, and important drawings are safely protected against fire.

The following is a summarization of the matters upon which the department was employed: —

Weston Aqueduct: Preliminary studies and investigations; contract drawings for sections 2, 3, 4, 5, 6, 8, 10, 11, 12, 13, 14 and 15, including chambers, culverts and other structures; land plans; detail drawings of siphon and other chambers, culverts and other features; studies for superstructures of head, siphon, channel, screen and terminal chambers; studies for head works, Section 1;

contract drawings for special castings and pipes for Section 1 and the siphon chambers; studies and drawings for sections 7 and 9, including the crossing of the Sudbury River; and map of aqueduct location.

Weston Reservoir: Preliminary studies; landscape treatment; dam; drainage around reservoir; Ash Street relocation and bridge over open channel; and contract drawings and specifications.

Wachusett Dam: Construction drawings for pool and spillway; construction drawings for upper and lower gate-chambers (unfinished); special castings, pipes and valves; power plant; superstructure for power house; and automatic registering gate.

Wachusett Aqueduct: Record drawings of culverts, highway bridges and Assabet bridge.

Wachusett Reservoir: Miscellaneous plans for hearings.

Relocation of Central Massachusetts Railroad: Studies for highway bridges.

Clinton Sewerage: Record drawings.

Diversion of Water: Drawings for Nashua River Paper Company's suit.

Sudbury Dam: Bronze tablet for inside of gate-house.

Improvement of Lake Cochituate: Snake Brook and Pegan meadows.

Chestnut Hill Reservoir: Screen closet and washing apparatus for effluent gate-house No. 2.

Southern High-service Reservoir: Forbes Hill masonry tower.

Distribution Department, Pipe Lines: Record drawings and diagrams relating to electrolysis.

Distribution Department, Miscellaneous: Screens, stop-planks, lifters for screens and stop-planks, sluice gates and floor plates for gate-houses; tests of Holly pumping engines (low and northern high service); assembly drawings of Holly low-service pumping engines; coal car handling apparatus for low-service pumping station; rearrangement of machinery in West Roxbury pumping station; and record drawings of pumping stations.

Miscellaneous: Diagrams of heights and conditions of reservoirs; drawings and tables for annual report of 1900; and indexing and filing drawings and calculation books.

In all, 195 finished drawings were made during the year, also many studies, sketches and computations.

Mr. Ferguson has continued in charge of the miscellaneous work of the office, such as receiving applications from those desiring employment, procuring supplies, making blue-prints and filing plans and records received from outside offices. He has furnished much assistance to the Conveyancing Department in the preparation of land plans, has made many investigations and computations, and has done much other work of so varied a character that it cannot be enumerated in a report. The average force in his department has numbered 8.

ACCIDENTS.

Seven fatal accidents have occurred during the year, 3 at the Wachusett Reservoir, 2 at the quarry which furnishes stone for the Wachusett Dam and 2 on the Weston Aqueduct.

All of those at the reservoir occurred in connection with the operation of trains; 2 on the railway used by Nawn & Brock and 1 on the railway used by Long & Little.

Of the 2 accidents which occurred at the quarry, the first occurred where a laborer slipped and fell a short distance, and one of the weights of the power drill with which he was working fell upon him, fracturing his skull; the second occurred when a laborer was loosening stone from one of the walls of the quarry with a bar, which fell upon him, causing almost instant death.

The first accident on the Weston Aqueduct occurred on Section 4, where an engineer of the stone crusher was fatally injured by falling into the fly-wheel when it was in motion; the second accident occurred on Section 12, where a mechanic who was erecting a bin for crushed stone was killed by the fall of one of the supports.

MAINTENANCE.

The additional works maintained and operated in 1901 are the Forbes Hill Reservoir, in Quincy, and the new pipe line to Stoneham.

ORGANIZATION OF MAINTENANCE FORCE.

At the beginning of 1901 the total maintenance force employed directly by the Board was 151, exclusive of such of the engineers as devoted only a part of their time to maintenance. At the end of the year the force had increased to 174. From time to time during the year there has been an additional temporary force engaged on special work, making the maximum number, including both the permanent and temporary force, 230.

RAINFALL AND YIELD.

In the last annual report reference was made to the drought of the summer of 1900, and the statement was made that it ended with the heavy rain of November 24–27.

Owing to the unprecedentedly low rainfall and flow of the streams from January 1 to March 10, this drought, which was partly broken in November, continued until March 10. As an instance of the severity of the drought for this season of the year, the average yield for the month of February on the Sudbury watershed was but 300,000 gallons per day per square mile, against the next lowest record in twenty-seven years of 541,000 gallons, and an average for this period of 1,889,000 gallons.

Immediately following this drought there was a remarkably large rainfall in March, April and May, amounting to 22.40 inches on the Sudbury watershed, or nearly one-half the rainfall for an average year, and a very large flow in the streams. During the summer the rainfall was abundant. In the autumn it was below the average, but in December it was more than double the average. Taking the year as a whole, the rainfall was about 20 per cent. above the average, and the flow from the Sudbury river watershed was 24 per cent. above the average.

Additional statistics relating to rainfall and yield of watersheds may be found in Appendix No. 3, tables 1 to 10.

STORAGE RESERVOIRS.

On January 1 the reservoirs on the Sudbury and Cochituate watersheds contained 8,839,100,000 gallons of water, or slightly more than one-half their total capacity. Owing to the unusual dryness of the season, already alluded to, the reservoirs, instead of rising, continued to lower until March 4, when they contained 7,075,700,000 gallons of water, and their low level at so late a date gave rise to apprehension that they would not be filled; but the succeeding heavy rains, beginning March 10, not only filled the reservoirs early in April, but furnished a large surplus to be wasted.

The reservoirs remained full until the latter part of June, when the storage decreased gradually to November 24, at which time there were 10,767,500,000 gallons of stored water in the reservoirs. From this time to the end of the year the storage increased.

The following table gives the quantity of water in the storage reservoirs at the beginning of each month. The second column gives the total in the reservoirs from which the supply is usually taken, the third column the storage in the other reservoirs, and the last column the total storage in all storage reservoirs.

Quantity of Water stored at the Beginning of Each Month.

DATE.	In Sudbury Reservoir and Framingham Reservoir No. 3 (Gallons).	In All Other Storage Reservoirs (Gallons).	Total (Gallons).
January 1, 1901,	5,205,900,000	3,633,200,000	8,839,100,000
February 1,	4,662,100,000	3,920,300,000	8,582,400,000
March 1,	3,555,900,000	3,654,200,000	7,210,100,000
April 1,	7,638,600,000	6,396,700,000	14,035,300,000
May 1,	8,465,200,000	7,544,000,000	16,009,200,000
June 1,	8,535,600,000	7,603,200,000	16,138,800,000
July 1,	8,278,500,000	7,591,500,000	15,870,000,000
August 1,	8,012,300,000	7,314,900,000	15,327,200,000
September 1,	7,766,900,000	6,923,700,000	14,690,600,000
October 1,	6,961,500,000	6,460,900,000	13,422,400,000
November 1,	6,163,800,000	6,129,500,000	12,293,300,000
December 1,	5,337,200,000	5,686,600,000	11,023,800,000
January 1, 1902,	7,127,200,000	6,712,900,000	13,840,100,000

NOTE. — The storage in Dudley Pond is included in this table.

Sudbury Reservoir. — At the beginning of the year the water in Sudbury Reservoir stood at elevation 252.54, which is 6.46 feet below the crest of the dam. The surface fell to elevation 246.90 on March 4, or 12.1 feet below the crest of the dam. The water then began to rise, and reached the level of the crest on April 3 and the top of the flash-boards on April 7. The surface remained near high-water level until June 23, when the draft on the reservoir beginning to exceed the supply, it lowered about 7.5 feet to elevation 252.32 on November 24. The water then began to rise, and reached elevation 257.35 at the end of the year, — 1.65 feet below the crest of the dam.

The Marlborough Brook filter-beds, at the head of one branch of the Sudbury Reservoir, have been in service throughout the year. They filtered all of the water of the brook except for short periods of less than a day each on eight occasions during freshet flows in

March, April, May and December. These filter-beds comprise 8.63 acres of natural and 5.36 acres of artificial beds. In cleaning the former it has been customary, until the present year, to harrow the surface of each of the beds after drying, leaving the dark-colored material upon the beds. During the year this fine organic deposit has been scraped into piles and removed from the beds. A large quantity of small stones has also been thrown out by the process of harrowing, and has been used for riprapping exposed portions of the banks. A similar method is pursued upon the artificial beds, which, however, have a surface of sand free from stones.

It is apparent that some method of renewing the sand surface from time to time must be adopted, in order to keep the depth of the filter-beds intact, and the best method of accomplishing this result is now under consideration. A large amount of work has been done in the way of repairing and improving different portions of the beds. The culvert under Walker Street, just above the settling reservoir, was rebuilt during the summer, at the joint expense of the city of Marlborough and the Commonwealth. Advantage was taken of this rebuilding to enlarge the culvert by adding 2 feet to its width.

Analyses have been made monthly by the State Board of Health of the water before and after passing through the filter-beds, and they show that the water was not purified by filtration to as satisfactory an extent as during the previous year. The average of all the examinations made during the year is as follows: —

[Parts per 100,000.]

	Before Filtration.	After Filtration.
Color (platinum standard),	0.33	0.14
Total residue on evaporation,	16.34	14.30
Loss on ignition,	5.01	-
Free ammonia,	0.1139	0.0505
Albuminoid ammonia,	0.0471	0.0191
Chlorine,	2.15	1.98
Nitrogen as nitrates,	0.2100	0.2147
Nitrogen as nitrites,	0.0074	0.0005
Oxygen consumed,	0.62	0.29
Hardness,	5.6	5.0

A number of improvements have been made around Sudbury Reservoir, principally in the planting of hemlock and white pine trees, rebuilding fences and grading the grounds around Sudbury Dam. Portions of the stable have been rebuilt and the cellar concreted and drained.

Framingham Reservoir No. 3, which derives its supply almost wholly from Sudbury Reservoir, was kept practically full throughout the year, with an extreme range in elevation of about 3 feet. From early in April until the middle of June, during which time the flash-boards were kept in position on the dam, the water was kept as high as possible; but during the remainder of the year it was kept about 1 foot below the crest, to prevent a waste of water from the effect of the wind.

In May a troublesome leak on the line of the old 48-inch pipe connecting Framingham dams Nos. 3 and 1 was repaired. It was necessary to sheet the trench and to use a steam pump to keep the excavation free from water.

Framingham Reservoir No. 2. — Beginning February 18, water was drawn in considerable quantities from this source for the supply of the Metropolitan District, lowering the water in the reservoir until March 9, when it was 7.4 feet below high-water mark. The level then rose rapidly. Except during the period mentioned, the reservoir has been generally full throughout the year.

Framingham Reservoir No. 1 has been kept practically full throughout the year.

Ashland Reservoir. — Water in this reservoir was about 11 feet below high-water mark at the beginning of the year. It rose gradually to about 7.2 feet below high-water mark on March 11, after which the water rose rapidly, and the reservoir remained full to the end of the year.

Hopkinton Reservoir. — Water in this reservoir was about 13 feet below high-water mark at the beginning of the year. Its level rose about 2 feet in the next two months. During the month of March it filled, and remained practically full during the remainder of the year.

Whitehall Reservoir was about 3 feet below high water at the beginning of the year, but by April 24 it had filled, and so remained until November 7, when the waste gate was opened, in order to lower the reservoir in anticipation of the winter and spring freshets. During the past year the old dredge and steamboat at Whitehall Reservoir have been sold and removed.

Farm Pond has been kept full throughout the year. An additional door of iron has been built in the principal gate-house, to give access to the aqueduct embankment which passes through the pond.

Lake Cochituate at the beginning of the year was about 8 feet below high-water level, and remained within a foot of this level until March 12, when it began to rise rapidly. It was full on April 13, and remained practically so until about July 1. After this the amount turned through the aqueduct caused it to lower at an almost uniform rate to a level about 7.5 feet below high water, on November 18. The water then began to rise, and at the end of the year was 2.71 feet below high water. Water was wasted at the outlet dam almost continuously from April 10 to June 11, and for two days at the end of the year.

In connection with the work of improving the Snake Brook Meadow, already described under the head of "Construction," the flow from 1.96 square miles of the Snake Brook watershed was diverted from the lake, in order to diminish as much as possible the amount of water to be pumped in connection with that improvement. In estimating the yield of the watershed allowance has been made for this diversion, and also for the amount of water pumped from the Snake Brook Meadow and diverted from the lake, as already described.

From January 2 to January 22, and from March 21 to April 8, water amounting in all to 543,600,000 gallons was discharged into the lake from the Sudbury Aqueduct.

No water has been drawn from Dudley Pond into the lake during the year. On January 1 the pond was 4.14 and at the end of the year 2.17 feet below high water, the highest point being reached on June 10, when the surface stood 1.42 feet below high water.

The Pegan Brook filter-beds in Natick have been in use for 278 days during the year. All of the brook water was filtered, except for portions of three days, when a small amount of water overflowed the settling reservoir and passed into the lake. At these times, however, freshets too large for the pumps to handle were passing down the brook, and the water was comparatively pure. The total quantity of water pumped from Pegan Brook during the year was 295,261,000 gallons; the total amount of coal consumed was 304,414 pounds, — making 970 gallons of water pumped per pound of coal.

Sources from which Water has been taken.

During the year the only water supplied from local sources was 21,200,000 gallons drawn by the city of Medford from Wright's Pond, and 193,400,000 gallons supplied by the Wakefield Water Company to the town of Stoneham, before it received water from the Metropolitan Water System on October 21, making in all an average of 588,000 gallons per day for the whole year from local sources. All of the supply, except this small quantity, was furnished by the Metropolitan Works, which furnished an average of 100,904,000 gallons per day. An average of 64,299,000 gallons per day was drawn from the South Branch of the Nashua River through the Wachusett Aqueduct into the Sudbury Reservoir. An average of 84,930,000 gallons per day was drawn through the Sudbury Aqueduct from Framingham Reservoir No. 3, which obtains its supply mainly from the Sudbury Reservoir. An average of 5,398,000 gallons per day was drawn from Framingham reservoirs Nos. 1 and 2, which receive all of the water supplied by the main Sudbury River. Of the water drawn from the Framingham reservoirs, an average of 1,489,000 gallons per day was turned into Lake Cochituate. An average of 14,890,000 gallons per day was drawn from Lake Cochituate.

The utmost care is taken to draw as little water as possible from the less satisfactory sources, and to draw the water only at such times as it is in good condition; but the maintenance of the supply with the existing condition of the works and the large consumption of water makes it necessary to draw some of the water from the less desirable sources.

It may be noticed that the total quantity of water passing into the Metropolitan District through the aqueducts is, according to the figures above given, somewhat in excess of the amount of water supplied from the Metropolitan Works to the District. In 1901, for the first time, all of the water for the District has been pumped, and the pump measurement, with a small allowance for slip, is used in determining the quantity. The quantities flowing through the aqueducts were determined by less exact methods, and are somewhat in excess of the actual quantity, but sufficiently accurate for indicating the proportion of water obtained from different sources.

AQUEDUCTS.

The *Wachusett Aqueduct* has been in continuous use throughout the year, except for twenty-five days, — April 4 to 15, April 24 to 29, May 28 to 30, December 15 to 21, and December 30 and 31, — when the water was quite turbid and not of a satisfactory quality to send through the aqueduct. During the time that there was no water running in the aqueduct, early in April, it was cleaned inside for its entire length. The average daily flow for the whole year has been 64,248,000 gallons per day.

Early in March alterations were made to the small flume and to the head works of the same at the temporary dam, so that 175,000,000 gallons of water per day could be sent through the aqueduct; and this flow has been generally maintained when there was sufficient water of good quality running in the river. Previous to the alterations, it was possible to send only about 130,000,000 gallons per day through the aqueduct.

From January 1 to March 11, March 16 to March 21, June 14 to October 14, and from October 20 to December 12, substantially all of the water in the river was turned through the aqueduct, except that which the provisions of the Metropolitan Water Act require shall be permitted to flow down the river, and a further quantity which filters into the excavation for the main dam and is pumped into the river below the dam.

The usual work of maintenance along the line of the aqueduct has been performed, and the aqueduct and its appurtenances are in excellent condition.

The *Sudbury Aqueduct* was in constant service during the year, except on the few occasions when it was necessary to empty it for cleaning. The total flow for the whole year averaged 90,328,000 gallons per day, which is 4,461,000 gallons more than the daily amount of water carried by the aqueduct last year. The interior was cleaned from Farm Pond gate-house to the terminal chamber at Chestnut Hill Reservoir, April 12, 18 and 25 and May 2. The siphon pipes were cleaned at the same time. The interior of the aqueduct was covered with a thick coating of black slime for its entire length. Sponge in small quantities was found in the Farm Pond gate-house, and gradually increased in quantity to the Rockland Street tunnel, where the bottom was entirely covered, as were also the sides from 2 to 4 feet in height. Badger Hill tunnel was in like condition. From the Badger Hill tunnel to the Beacon Street tunnel sponge was found in varying quantities, but in the Beacon Street tunnel no sponge was found.

The stairway at Echo Bridge over the Charles River has been completed and the grounds graded.

During the year the city of Newton laid a main sewer in tunnel through the rock on each side of the Charles River, passing beneath the large arch at Echo Bridge in the bed of the river in two siphon pipes. A large amount of blasting was done on each side of the bridge, requiring special care to prevent ill effects on the masonry of the bridge. Advantage was taken of the drawing down of the water in the Charles River at this time to examine carefully the condition of the foundations upon which the abutment of the large arch of Echo Bridge rests. On the easterly side of the stream the ledge is not of very good character, and a retaining wall was built to aid in securing its stability.

New fencing 8,640 feet in length has been built along the line of the aqueduct, and 10,912 feet of old fence have been repaired.

The interior of the arches at Waban Bridge were heated with steam during the winter months, which prevented the formation of ice inside the bridge.

As the aqueduct is run much of the time to its full capacity, great care has to be takên to prevent it from being overcharged. As additional precautions to those previously provided, a recording float gage to indicate the depth of the water in the aqueduct has been installed at the South Framingham office, and a telephone has been placed in the gate-house at Framingham Dam No. 1. The flows in the aqueduct have been checked frequently throughout the year by current meter measurements.

The *Cochituate Aqueduct* was in use about three hundred and seven days. Advantage was taken of the opportunity between May 7 and June 11, when the aqueduct was not in use, to continue the repairs of cracks in the aqueduct on embankments. Last year they had been completed from the upper end of the aqueduct to and including Seaver's embankment, easterly from the Waban station in Newton. All of the cracks easterly from this point, as far as the Newton Centre waste weir, were repaired, also the cracks in the top of the aqueduct as far as Homer Avenue, about 1,400 feet easterly from the waste weir.

The interior of the aqueduct was cleaned for its whole length on May 9, 10 and 11. The brickwork was covered with a black slime for its entire length, and sponge was found in large quantities from the lake to Stevens' Brook, gradually diminishing from this point to Chestnut Hill Reservoir.

New flap-gates of kyanized lumber were placed in position at the outlet pipe chamber on the two 30-inch and the 36-inch siphon pipes. Quite extensive repairs have been made on the exterior stone work of the structures connected with the aqueduct.

The channel of Snake Brook was cleaned for a distance of 2,400 feet near the village of Cochituate, where the brook passes over the line of the aqueduct. For the purpose of diverting the waters of the brook from the lake, a dam containing a plank sluiceway was built across the aqueduct. This work was done in connection with the excavation of Snake Brook Meadow, described under the head of "Construction."

The aqueduct line has been crossed several times during the year by small culverts and water pipes and telephone conduits.

PUMPING STATIONS.

With the exception of 102,980,000 gallons of water drawn by the city of Boston from the Brookline Reservoir, while one of its 48-inch pipe lines was being repaired, all of the water supplied by the Metropolitan Water Works during the year has been pumped at the two stations at Chestnut Hill Reservoir.

The supply for the northern high-service district is again pumped at Spot Pond to the Fells Reservoir, and the supplies for the southern extra high-service district in West Roxbury and the northern extra high-service district in Arlington are pumped a second time at the small stations in West Roxbury and Arlington.

On account of the unavoidable discontinuance — mentioned in last year's report — of the pipes supplying the high-service district of Breed's Island in East Boston, the old pumping station in East Boston belonging to the city of Boston was operated by the Board until June 20.

The present daily pumping capacity of the five stations operated by the Board is 204,500,000 gallons, and the force employed in these stations numbers 48.

The total quantity pumped at all of the stations during the year was 40,018,920,000 gallons, and the cost of operating the stations was $100,650.94, equivalent to $2.52 per million gallons pumped. This is $0.82 per million gallons less than for the preceding year, due to the large increase in the quantity pumped for the low service, and to the use of more economical machinery.

The saving effected in the cost of pumping by the discontinuance of the many small stations which were operated in the several cities and towns previous to 1898 and by pumping the supply with more economical machinery at a few large stations is illustrated by the following statement: —

	Cost of Pumping.	Million Gallons Pumped.	Cost per Million Gallons.
1897, ...	$122,400 00	12,700	$9 64
1901, ...	100,650 94	40,019	2 52

Chestnut Hill High-service Station.

The engines at this station have pumped the supply for the high-service district of Boston, also the entire supply of the city of Quincy and the towns of Watertown and Belmont. Engines Nos. 1, 2 and 3 have also been used to pump a small portion of the low-service supply. The 30,000,000-gallon Allis engine pumped 80.6 per cent. of the entire quantity pumped at the station.

The following are the statistics relating to the operations at this station: —

	Low Service.		High Service.			Totals.
	Engines Nos. 1 and 2.	Engine No. 3.	Engines Nos. 1 and 2.	Engine No. 3.	Engine No. 4.	
Total quantity pumped (million gallons), .	204.51	645.58	202.47	1,016.57	8,584.11	10,653.24
Total coal used (pounds), ...	310,069	482,009	499,756	953,488	6,346,061	8,591,383
Gallons pumped per pound of coal, . .	1,077.18	1,478.94	608.13	1,102.38	1,352.67	1,239.99
Average head pumped against (feet), .	48.13	67.77	124.33	125.25	126.31	121.13
Cost of pumping: —						
Labor, ...	$788 27	$945 92	$630 61	$1,576 53	$11,823 98	$15,765 31
Fuel, ...	594 40	924 01	958 03	1,827 84	12,165 86	16,470 14
Repairs, ...	485 00	442 00	485 00	834 59	2,092 37	4,338 96
Oil, waste and packing, ...	30 00	50 00	30 00	100 00	557 37	767 37
Small supplies, ...	48 92	65 22	48 92	97 83	554 39	815 28
Total for station, ...	$1,946 59	$2,427 15	$2,152 56	$4,436 79	$27,193 97	$38,157 06
Cost per million gallons pumped to reservoir,	$9 518	$3 760	$10 632	$4 364	$3 168	$3 582
Cost per million gallons raised 1 foot high,	198	055	086	035	025	030

Coal has been purchased for use at this station as follows: 3,981.25 gross tons bituminous coal, at an average price of $4.45 per ton; 545.63 gross tons anthracite coal screenings, at an average price of $2.25 per ton.

The cost per million gallons raised 1 foot high was $0.03, which is almost exactly the same as the cost for the previous year. As the quantity pumped at this station was about 33 per cent. less than during 1900, and as the cost of coal was $0.57 per ton greater, the result is a satisfactory one.

At the beginning of the year two horizontal tubular boilers were being set in the boiler room, replacing two boilers installed with the Gaskill engines in 1885. The new boilers are designed to carry 185 pounds of steam pressure, so that they can be used in connection with any of the engines in the station. The boilers were placed, the brick setting built and all of the small piping done by the regular maintenance force. The steam piping connecting with other boilers and with engines Nos. 1 and 2 was done by the William H. Gallison Company, at a cost of $1,365.71. Magnesia covering was applied to the piping by S. C. Nightingale & Childs, at a cost of $210. The work was completed and the boilers placed in service on March 23.

A new toilet room with slate partitions and modern fixtures has been built in the basement, and connections made with the new sewer built in 1900. This work was done by James Tucker & Sons, at a cost of $745.

The Belpaire boiler which was added to the plant in 1894 has for a number of years given considerable trouble on account of cracks in the side furnace plates, and after careful consideration it has been decided to replace this boiler by two vertical boilers of the same design as those in use at the low-service and Spot Pond stations. Plans are now being made, and the boilers will be built during the coming year.

The exterior woodwork of the building has been painted, the interior oak finish of the engine room varnished and the floor cleaned and varnished. In order to strengthen engine No. 4, the Allis-Chalmers Company has at its own expense placed five cast-steel supports between the pump chambers and the under side of the engine bed-plates.

Chestnut Hill Low-service Station.

The three 35,000,000-gallon engines at this station have pumped a daily average for the entire year of 72,204,000 gallons, or 71 per cent. of the total consumption of the municipalities supplied by the Metropolitan Works. They have continued to operate very satisfactorily, and both engines and boilers are now in good condition.

The following are the statistics relating to operations at this station: —

	Engines Nos. 5, 6 and 7.
Total quantity pumped (million gallons),	26,354.40
Total coal used (pounds),	8,528,670
Gallons pumped per pound of coal,	3,090.09
Average head pumped against (feet),	48.37
Cost of pumping: —	
Labor,	$20,319 34
Fuel,	16,916 36
Repairs,	432 41
Oil, waste and packing,	854 83
Small supplies,	1,065 03
Total for station,	$39,587 97
Cost per million gallons pumped to reservoir,	$1 502
Cost per million gallons raised 1 foot high,	031

Bituminous coal for use at the station has been purchased as follows: —

Loyal Hanna Coal and Coke Company,	471.78 gross tons, at $4.78 per ton.
Loyal Hanna Coal and Coke Company,	977.26 gross tons, at $4.29 per ton.
Loyal Hanna Coal and Coke Company,	2,401.30 gross tons, at $4.34 per ton.

Spot Pond Pumping Station.

At this station engine No. 8 was operated a few days in February; twelve days in May, while arrangements were being made for the official trial of engine No. 9, and from September 10 to October 11, while engine No. 9 was being painted. With these exceptions the new Holly engine has pumped all of the water at this station. As a rule it is operated only in the day time.

The following are the statistics relating to operations at this station: —

	Engine No 8.	Engine No. 9.	Totals.
Total quantity pumped (million gallons),	351.89	2,414.53	2,766.42
Total coal used (pounds),	344,975	2,076,021	2,420,996
Gallons pumped per pound of coal,	1,020.04	1,163.06	1,142.68
Average head pumped against (feet),	114.54	119.50	118.87
Cost of pumping: —			
Labor,	$1,024 51	$6,564 43	$7,588 94
Fuel,	678 99	4,086 03	4,765 02
Repairs,	15 03	15 03	30 06
Oil, waste and packing,	54 74	218 98	273 72
Small supplies,	144 66	578 66	723 32
Total for station,	$1,917 93	$11,463 13	$13,381 06
Cost per million gallons pumped to reservoir,	$5 450	$4 748	$4 887
Cost per million gallons raised 1 foot high,	048	040	041

Coal for use at the station has been purchased as follows: —

Locke Coal Company (bituminous),	1,000.05 gross tons, at $4.37 per ton.
Locke Coal Company (anthracite screenings),	13.14 net tons, at $2.00 per ton.

West Roxbury Pumping Station.

During the past year both the pumps and boilers at this station have been replaced by others of larger capacity. The two new pumps have each a capacity of 1,000,000 gallons in twenty-four hours, and are of the compound duplex type, built by the Henry R. Worthington Company of New York. They were purchased from the city of Boston, having been formerly used in the East Boston pumping station. Two new boilers, 54 inches in diameter and 9 feet high, containing 184 2-inch tubes, 6½ feet long, were furnished by E. Hodge & Co. of East Boston. A Wainwright surface condenser, 16¼ inches in diameter and 7 feet 4 inches long, and a Snow single air pump, 4 inches by 4¾ inches by 8 inches, were also added to the plant. The old pumps and boilers were removed and the new plant installed without interrupting the regular operation of the station, the work being all done by the regular employés of the department. The boilers were delivered June 10, and the work was completed during the latter part of July. The old pumps and boilers belonging to the city of Boston were returned to the Boston Water Department yard.

The following are the principal items of cost of the work: —

Two pumps,	$400 00
Two boilers,	1,197 66
Air pump,	126 00
Surface condenser,	210 00
Covering boilers and piping,	93 78
Teaming pumps and boilers,	59 00
Piping and valves,	198 34
Labor taking out old and installing new pumps and boilers,	891 79
Miscellaneous,	193 69
Total,	$3,370 26

A saving of between 30 and 40 per cent. of the coal burned has been made by installing the new pumps and boilers.

In November, the boilers, engines and piping were painted, the interior woodwork of the building varnished and the outside woodwork painted.

The following are the statistics relating to operations at this station: —

Daily average quantity of water pumped (gallons),	334,000
Daily average quantity of coal consumed (pounds),	1,834
Gallons pumped per pound of coal,	182
Average lift in feet,	135
Cost of pumping: —	
Labor,	$2,850 60
Fuel,	1,961 00
Repairs and small supplies,	109 97
Total for station,	$4,921 57
Cost per million gallons pumped to reservoir,	$40 310
Cost per million gallons raised 1 foot high,	299

Arlington Pumping Station.

The supply for the high-service district of the town of Arlington is pumped at this station.

The following are the statistics relating to operations at this station: —

Pumps operated 4,379 hours 45 minutes; average, 12 hours per day.

Daily average quantity of water pumped (gallons),	309,000
Daily average quantity of coal consumed (pounds),	1,746
Gallons pumped per pound of coal,	177
Average lift in feet,	278
Cost of pumping: —	
Labor,	$2,077 22
Fuel,	1,199 13
Repairs and small supplies,	144 68
Total for station,	$3,421 03
Cost per million gallons pumped to standpipe,	$30 340
Cost per million gallons raised 1 foot high,	109

The quantity pumped was 1.7 per cent. greater than for the previous year, and the cost per million gallons pumped to the standpipe was very nearly the same.

East Boston Pumping Station.

The supply for the small district on Breed's Island was pumped at the East Boston station belonging to the city of Boston from January 1 to June 20, when the work of relaying pipes in Bennington Street was completed, so that the supply could be taken from the Fells Reservoir.

The cost of operating this station was $731.25.

CONSUMPTION OF WATER.

The daily average quantity of water consumed in the cities and towns of the Metropolitan Water District supplied wholly or in part by the Metropolitan Water Works during the year 1901 was 101,492,000 gallons, equivalent to 120 gallons per inhabitant in the district supplied. Of the above, 100,904,000 gallons per day were supplied by the Metropolitan Water Works and 588,000 gallons per day from local sources. The increase in the daily average consumption in the cities and towns supplied over that of the previous year was 6,742,000 gallons, or 7.1 per cent. During the summer months the consumption was but little greater than for the corresponding months of the previous year, due in great measure to the large amount of rainfall. During the months of January, February and December, however, the consumption averaged 15,000,000 gallons per day more than during the corresponding months of the year 1900. This was due in great measure to the colder weather during these months in 1901.

The consumption and percentage of increase over the previous year in the several districts was as follows: —

	Gallons per Day.	Percentage of Increase.
Southern low-service district, embracing the low-service district of Boston, with the exception of Charlestown and East Boston,	39,754,000	2.2
Northern low-service district, embracing the low-service districts of Somerville, Chelsea, Malden, Medford, Everett, Arlington, Charlestown and East Boston,	26,501,000	11.4
Southern high-service district, embracing the high-service district of Boston, Quincy, Watertown and Belmont,	26,496,000	10.3
Northern high-service district, embracing Melrose, Revere, Winthrop, Swampscott, Nahant and Stoneham, and the high-service districts of Somerville, Chelsea, Malden, Medford, Everett and East Boston,	8,098,000	18.0
Southern extra high-service district, embracing the highest portions of West Roxbury,	334,000	—6.0
Northern extra high-service district, embracing the highest portions of Arlington,	309,000	1.3

The percentages of increase given above do not in all cases accurately represent the increase in the per capita consumption, because changes were made in the boundaries of the districts. In May, 1900, portions of Roxbury and West Roxbury were changed from low to high service. This affects slightly the percentages of increase given for the southern low and southern high services. The water used in Stoneham during 1901 is included in the consumption of the northern high-service district, but it was not included for the year 1900. If the consumption of Stoneham is included in that of the northern high-service district in 1900, the percentage of increase would be 9.3, instead of 18. The decrease in the consumption in the southern extra high-service district was due in part to the transfer of a number of water takers to a lower service, and in part to a too small allowance for slip in the pumps for the year 1900.

Detailed statistics of the consumption of water may be found in Appendix No. 3, tables 20 to 26.

Quality of the Water.

Samples of water were collected every two months from eight points, monthly from eight points and weekly from three points upon the works, and sent to the State Board of Health for analysis and examination. Samples of water were also collected each week from many points upon the works, and examined microscopically and for color, odor, taste and turbidity by the biological force of the Metropolitan Water and Sewerage Board.

The quality of the water furnished was about the same as that of the previous year. The average color was exactly the same. As far as shown by the chemical examinations by the State Board of Health, the tap water of the main portion of the Metropolitan supply was not quite as good, while as far as concerns freedom from microscopical organisms, shown by the examinations under the direction of the Metropolitan Water and Sewerage Board, the water was better. The mineral constituents and hardness of the water were considerably in excess of the previous year, but this excess has much less significance than if it occurred in the organic matter.

Although a larger supply was furnished to the Metropolitan District, due to increased consumption, a smaller proportion of water was drawn from Framingham Reservoir No. 2 and Lake Cochituate, which are generally less satisfactory sources than Framingham Reservoir No. 3 and Sudbury Reservoir, from which the main supply was taken. The latter receive the greater part of their water from the Nashua River, and other things being equal, the quality of the water in the main part of the distribution system should have been better than that for the previous year.

The amount and distribution of the rainfall, however, were such that the quality of the water flowing in the streams was not quite so good during 1901 as in 1900. In the year 1900, owing to the drought, the flow in the main channel of the Sudbury River was very small, and consequently it was feasible to run the stored water from the Ashland and Hopkinton reservoirs into Framingham Reservoir No. 2 with only a small admixture with the less satisfactory river water. In this way a water of satisfactory quality was supplied to and drawn from Framingham Reservoir No. 2 until the latter part of February, 1901, but after the heavy rains began, in March, and during the remainder of the year, the flow in the river was so large that the stored water from the upper reservoirs could not be turned into Framingham Reservoir No. 2 except with a large admixture of river water, which was not of satisfactory quality, consequently no water was drawn from these reservoirs during the year. During the past year, also, the waters supplied to the Sudbury Reservoir and to Framingham Reservoir No. 3 from the Sudbury River watershed, and also the water supplied to Lake Cochituate from the Cochituate watershed, were not of as good quality as during the previous year.

The following table gives a comparison of the average results of examinations of Boston tap water made for the years 1897, 1898, 1899, 1900 and 1901. The additional supply from the South Branch of the Nashua River first reached the Metropolitan District about May 1, 1898.

	1897.	1898.	1899.	1900.	1901.
State Board of Health Examinations.					
Color (Nessler standard),	0.65	0.41	0.23	0.24	0.24
Total residue,	4.82	4.19	3.70	3.80	4.43
Loss on ignition,	1.84	1.60	1.30	1.20	1.64
Free ammonia,	0.0009	0.0008	0.0006	0.0012	0.0013
Albuminoid ammonia, total,	0.0193	0.0152	0.0136	0.0157	0.0158
Albuminoid ammonia, dissolved,	0.0177	0.0136	0.0122	0.0138	0.0143
Albuminoid ammonia, suspended,	0.0016	0.0016	0.0014	0.0019	0.0015
Chlorine,	0.40	0.29	0.24	0.25	0.30
Nitrogen as nitrates,	0.0187	0.0097	0.0137	0.0076	0.0173
Nitrogen as nitrites,	0.0001	0.0001	0.0001	0.0001	0.0001
Oxygen consumed,	0.64	0.44	0.35	0.38	0.42
Hardness,	1.6	1.4	1.1	1.3	1.7
Metropolitan Water and Sewerage Board Examinations.					
Color (platinum standard),	0.59	0.40	0.32	0.34	0.34
Total organisms,	351	230	192	468	243
Amorphous matter,	177	131	201	97	38
Bacteria,	105	96	117	181	162

NOTE. — Chemical analyses are in parts per 100,000, organisms and amorphous matter in standard units per cubic centimeter, and bacteria in number per cubic centimeter. The standard unit has an area of 400 square microns, and by its use the number of diatomaceæ are decreased, and the number of chlorophyceæ and cyanophyceæ are very much increased, as compared with the number of organisms.

The filling of Spot Pond from the Sudbury and Cochituate sources, referred to in the last report, had been interrupted in December, 1900, by drought, but was resumed in the spring of 1901, and on April 9 the pond was entirely full. From April 9 until the beginning of the summer the water in Spot Pond contained a considerable number of microscopical organisms, but it improved rapidly during the summer, and under the influence of storage it became the best water in the Metropolitan system. The color was reduced to .08 on the platinum scale, which was about one-third of the color of the main supply at the same time, and the organisms were few in number. The water was accordingly used as far as practicable, but in the autumn the microscopical organisms increased to such a degree as to give a slightly unpleasant taste and odor to the water, and on December 12 the pond was shut off from the supply.

Appendix No. 3, tables 27 to 35, gives the detailed results of chemical, microscopical and bacterial examinations of water from various parts of the Metropolitan Water Works.

Biological Laboratory.

On December 24 Mr. Horatio N. Parker, chief biologist, resigned to accept a position in New Jersey, his resignation to take effect January 1, 1902.

During the year 2,954 microscopical and 1,249 bacterial examinations of water were made at the laboratory of the Metropolitan Water and Sewerage Board, at No. 1 Ashburton Place, Boston. Of the microscopical examinations, 2,121 were of the regular weekly samples and 473 were made in connection with special examinations. During the whole of the past year and during the last three months of the preceding year, in addition to the usual observations, the odors of the water, cold and hot, were observed and classified with reference to strength and character. Their strength is indicated by a series of numbers ranging from 0 to 5, or from no odor to a very strong odor. The character of the odor is classified under 16 different heads.

The turbidity of the water was also measured by comparing the samples with a standard consisting of diatomaceous earth suspended in water in which a turbidity of 1 is represented by 1 part of diatomaceous earth in 1,000,000 parts by weight of distilled water.

Some advance has been made every year in the way of refinement of methods used in the laboratory. Information promptly obtained and reported, relative to the character of the water and the organic growths which it contains, is of great value in the management of the works, as it furnishes a guide for making changes in the method of drawing water so as to obtain the best results.

The principal results of the work done by the biological force are given in Appendix No. 3. Table No. 34 gives the results of the microscopical examinations, Table No. 35 the bacterial examinations, Table No. 36 the turbidity, Table No. 37 the colors of the water, and tables Nos. 38 and 39 the temperatures of the water and of the air.

SANITARY INSPECTION.

The sanitary inspection of the Sudbury, Cochituate and Wachusett watersheds has been continued during the year under the direction of William W. Locke, C.E., sanitary inspector. The greater part of the inspection has been done upon the Sudbury and Cochituate watersheds, where there is a large population, but a much larger amount of work than heretofore has been done on the Wachusett watershed, and the results obtained continue to be very satisfactory.

A summary of the work done in 1901 upon the Sudbury and Cochituate watersheds is given in the accompanying tables. The first table shows the number of premises inspected, the classification of cases inspected and the condition of the premises at the end of the year. The headings of this table explain themselves, except in a few instances; under the heading "Suspected" are included all cases where positive information could not be obtained, and where it is suspected that there may be some objectionable drainage; under the heading "Premises Vacant" are included all cases which at present furnish no objectionable drainage, but which might furnish such drainage if the premises were occupied; under the heading "Unsatisfactory" are included all cases where there may be, under the most unfavorable conditions, wash from privies or direct sink drainage, all suspected cases and all cases of manufacturing wastes entering feeders, even though there may be some attempt at previous purification.

The second table shows the improvements effected in 1901. No cases are entered as remedied unless complete sewer connections have been made or all probability of future contamination has been removed, and no cases are entered as partly remedied except where positive improvement in the sanitary condition has been effected.

Summary of Sanitary Inspections in 1901.

DISTRICT.	Number of Premises Inspected.*	CLASSIFICATION OF CASES INSPECTED.									CONDITION AT END OF YEAR.	
		Cesspools dug before 1901.	Cesspools dug in 1901.	Direct Privy Drainage.	Indirect Privy Drainage.	Direct Sink Drainage.	Indirect Sink Drainage.	Manure Piles.	Manufacturing Wastes.	Premises Vacant.	Satisfactory.	Unsatisfactory.
Sudbury Watershed.												
Farm Pond,	3	1	-	-	-	-	1	1	-	-	3	-
Framingham Reservoir No. 3,	7	5	1	-	-	-	1	2	-	1	7	-
Stony Brook,	53	31	-	-	-	2	5	7	1	8	48	5
Angle Brook,	391	200	7	-	3	9	68	28	5	35	345	46
Framingham reservoirs Nos. 1 and 2 and Cold Spring Brook,	26	19	-	-	-	-	5	2	-	2	24	2
Eastern Sudbury,	36	17	1	-	-	-	12	1	-	10	32	4
Indian Brook,	48	25	-	-	-	-	16	3	-	3	36	12
Western Sudbury,	22	12	1	-	-	-	8	2	1	2	18	4
Whitehall Reservoir,	7	3	-	1	-	1	1	3	-	-	5	2
Cedar Swamp,	56	27	1	-	-	-	8	-	1	2	50	6
Cochituate Watershed.												
Snake Brook,	38	17	3	-	1	-	12	4	-	3	31	7
Pegan Brook,	169	65	1	-	2	-	10	11	3	4	155	14
Course Brook,	6	3	-	-	-	-	2	-	-	-	4	2
Beaver Dam Brook,	119	60	1	-	1	4	18	7	7	4	100	19
Totals,	981	485	16	1	7	16	167	71	18	74	858	123

* Not including a large number of premises which were found on examination to be in a satisfactory sanitary condition, and likely to remain so. On some premises there are two or more cases.

Sanitary Improvements effected on the Sudbury and Cochituate Watersheds in 1901.

DISTRICT.	Remedied by Sewer Connections.	Otherwise remedied.	Partly remedied.	Cesspools abandoned on Account of Sewer Connections.
Sudbury Watershed.				
Farm Pond,	-	-	-	-
Framingham Reservoir No. 3,	-	-	1	-
Stony Brook,	-	-	-	-
Angle Brook,	44	4	7	47
Framingham reservoirs Nos. 1 and 2 and Cold Spring Brook,	-	-	-	-
Eastern Sudbury,	-	-	1	-
Indian Brook,	-	-	-	-
Western Sudbury,	-	-	1	-
Whitehall Reservoir,	-	-	-	-
Cedar Swamp,	17	-	1	17
Cochituate Watershed.				
Snake Brook,	-	-	2	-
Pegan Brook,	73	1	-	71
Course Brook,	-	-	-	-
Beaver Dam Brook,	28	5	1	25
Totals,	162	10	14	160

In towns containing sewers, the making of sewer connections has been pushed through the agency of the local boards of health, with satisfactory results.

In Natick 73 old houses have been completely plumbed and connected with the public sewers, — about the same number as during each of the past two years. The area of the sewered districts is being increased each year by the building of new sewers.

In Marlborough there has been a falling off in the number of sewer connections, as compared with the previous year, 44 houses having been completely plumbed and connected with the sewers the past year, against 58 the previous year.

In South Framingham 28 houses have been completely plumbed and connected during the past year, as compared with 14 during the previous year. The new low-level sewer along Beaver Dam Brook has been completed only from the sewerage pumping station to Irving Street, and until this sewer is extended it will not be available for any large part of the district which it is intended to serve. Only 3 houses have been connected with the sewer up to the present time.

In Westborough 17 sewer connections have been made, against 12 the previous year.

The sanitary inspection of the Wachusett watershed, which is connected with both the construction and maintenance of the work, has been reported upon under the head of "Construction."

DRAINAGE OF SWAMPS.

No additional ditches for the drainage of swamps have been constructed during 1901. The ditches previously constructed by the Dam and Aqueduct Department on the Wachusett watershed and on the part of the Sudbury watershed tributary to the open channel have been maintained by the maintenance force of the Dam and Aqueduct Department. It has required most of the time of two men to take care of the 15.55 miles of ditches on the Sudbury watershed.

Observations of the color of water from Crane Swamp and from the swamp southwest of Marlborough Junction before and after draining were given in the last annual report. The average colors of the waters issuing from these swamps in 1900 were, respectively, .82 and .47; for the year 1901 the average colors were, respectively, 1.04 and .66. The higher colors in 1901 are due to the larger amount of rainfall in the warmer part of the year. The colors in 1901 were a little less than one-half the colors in 1894–95, before the swamps were drained.

The ditches built by the Sudbury Department were finished so late in the season of 1900 that no opportunity was afforded for protecting the sides of the ditches above the paving by seeding or sodding, and a considerable amount of damage was done by the frost and the heavy flows of water in the spring. The wooden bottoms of the ditches were not disturbed, but much damage was done to the paving and earth work at the sides. In the summer, extensive repairs were made. In some places the work could be done rapidly by ramming the paving back into place and sodding the banks, but in other places much more work was required.

Distributing Reservoirs.

The distributing reservoirs maintained by the Board are the Chestnut Hill Reservoir, Waban Hill Reservoir and Forbes Hill Reservoir and standpipe, of the southern high-service system; Spot Pond and the Mystic Distributing Reservoir near Tufts College, of the low-service system; the Fells Reservoir, of the northern high-service system; and the Arlington standpipe, of the northern extra high-service system.

Chestnut Hill Reservoir.

A much-needed improvement has been made to the surface water drains in the vicinity of the intermediate gate-house. The old pipes were not large enough to carry the heaviest rainfalls, and nearly 600 feet of drain pipe from 6 inches to 12 inches in diameter were laid, 5 catch-basins remodelled or rebuilt, and a new catch-basin and a new man-hole built. The drain can now take care of a rainfall of 2 inches per hour.

A large amount of surfacing of the driveways around the new low-service pumping station was done early in the year by the force in charge of the reservoir. Extensive repairs have been made upon the window frames and roofs of several of the gate-houses, and the usual care has been bestowed upon the maintenance of the reservoir and surrounding grounds.

Waban Hill Reservoir.

The slope paving on two sides of this reservoir, which had settled so as to be unsightly in appearance, has been relaid for from 10 to 20 feet down from the top of the slope, and the masonry of the gate-house and entrance steps repointed. A considerable portion of the reservoir embankments was reseeded. The reservoir was kept full of water, but shut off from the system for the greater part of the year.

Forbes Hill Reservoir and Standpipe.

The reservoir was placed in service on September 23, 1901; the stand-pipe has been in use during the whole year, and is in good condition.

Spot Pond.

On January 1, 1901, the elevation of the surface of the water in the pond was 159.47 feet above Boston city base, or 3.53 feet below high-water mark. It was kept near this level until early in the month of March, when water was pumped into the pond; and on April 9 the surface reached elevation 163, or high-water mark. The pond was kept full until the middle of September, when it was lowered about 2 feet, in order to facilitate the work of pipe laying in Pond Street. About October 13 it was again raised, reaching elevation 163 on November 12. Early in December the water in the pond acquired an objectionable taste and odor, from the presence of microscopic organisms, and since December 12 no water has been drawn from the pond for supplying the district. Some repairs have been made to the riprap and gravel beaches on the shore of the pond, the trees have been cared for, drains cleaned, and nine tons of straw harvested for the use of the department.

Mystic Reservoir.

The embankments were fertilized in the spring. Screens have been placed in what was formerly the inlet to the reservoir, as the supply for Arlington is at times drawn from the reservoir at this point.

Fells Reservoir.

This reservoir has been in constant use, and has been kept near high-water mark, with the exception of periods of about two weeks in the latter part of the month of April, while the reservoir was being cleaned, and three weeks following May 22, when arrangements for measuring over a weir the quantity of water pumped necessitated lowering the height of the water. Between April 16 and May 1 both basins of the reservoir were emptied and cleaned, at a cost of $468.87.

MYSTIC LAKE.

Two buildings formerly used for a temporary pumping station have been leased to the Medford Boat Club, and one of the storehouses has been torn down. One man has been employed to look after the grounds and to control the height of water in the lake.

PIPE YARDS.

At the Glenwood pipe yard the outside woodwork of the office and stable building was painted, and portions of the walls were pointed. The mast of the derrick was fitted with truss rods, in order to strengthen it for handling 60-inch pipe.

At the Chestnut Hill pipe yard a platform scale has been set up. The exterior woodwork of the stable has been painted, also the interior finish in the carriage room.

PIPE LINES.

At the close of the year there were 72 miles of pipe lines controlled by the Board. During the year 3 breaks and 30 leaks have been repaired, at a cost of $2,699.63. Two of the breaks and 3 of the leaks were in Somerville, on mains taken from the city of Boston; 16 of the leaks occurred at the joints of the 36-inch submerged pipes under the Charles and Mystic rivers. Similar leaks occurred last year in the autumn, and they are caused by the contraction of the pipes, due to the falling temperature at this season of the year. In November the 36-inch pipes crossing the Charles River near Magazine Street in Cambridge were tested and found to be leaking. Examination by diver disclosed 2 leaks, and after these were repaired others were found. As the pipes are buried several feet below the surface of the river bed, a dredge was required for excavating the earth around the pipes before the diver could reach the joints, and the work of making repairs was slow and expensive. Work was continued from November 26 to December 31, 6 leaks having been repaired, at a cost of $1,790.

The leaks at the Mystic River crossing between Somerville and Medford were repaired by the regular maintenance force, as they could be reached during extreme low tide without the services of a diver.

The construction of the tunnel under the channel of the Mystic River between Charlestown and Chelsea, in which to place a 24-inch pipe, was begun by C. W. Haskin on August 20, 1900, and at the beginning of 1901 one shaft and the greater portion of the tunnel were finished. The second shaft and the remainder of the tunnel were completed about the middle of February, and the pipes were laid by the maintenance force and placed in service March 15. Both shafts and tunnel are 6 feet internal diameter, with walls of 12-inch brick masonry laid in Portland cement. From the top of each shaft to a depth of about 45 feet there is a ½-inch wrought-iron shell outside the brick masonry. The shafts are 62 feet in depth and 139½ feet from centre to centre. The leakage into the tunnel after the work was finished averaged about half a gallon per minute.

The total cost of the work, including the reconstruction of the wooden boxing at each end and repairing fender guard, but not including the cost of laying the pipes, was $21,850.69.

Considerable time and labor have been devoted to making changes in the 24-inch pipe line in Adams Street in Milton and Quincy, made necessary by the work of constructing the Metropolitan sewer in the street. In March a temporary 12-inch line, 250 feet long, was laid around a tunnel shaft near Washington Street, and 180 feet of the 24-inch pipe temporarily abandoned. On August 1 and 2 the connections at the junction of Adams and Beale streets were relocated. In September about 260 feet of 16-inch and 20-inch pipe were laid for temporary use during the construction of the sewer, 150 feet of 24-inch pipe taken up, and 316 feet of 24-inch pipe moved laterally from 1 to 8 feet in order to make room for the sewer trench. On November 27 the location of the pipe was changed for a distance of 125 feet near the corner of Church Street. Watchmen were kept on the ground for several weeks, and the main was shut off a number of times on account of the caving of the sewer trench.

Between May 20 and June 20, 116 feet of 12-inch pipe were raised and 1,377 feet were relaid on Bennington Street in East

Boston, to conform with the revised line and grade where the street had been filled during the previous year.

The ironwork of the bridges supporting the pipes over the Boston & Maine Railroad at Walnut Street and College Avenue in Somerville, the Fitchburg Railroad at Massachusetts Avenue in Cambridge, and the Boston & Albany Railroad at St. James Street in Newton, has been thoroughly cleaned and painted.

For the purpose of recording the pressure in the pipes at different parts of the Metropolitan District, additional Jones recording pressure gages have been established at the gate-house of the Mystic Reservoir and at the offices of the Medford and Quincy water departments. The gage formerly located in the office at No. 3 Mt. Vernon Street has been placed in the fire engine house on Bulfinch Street. At present, 17 of these gages are in use and the records are filed at this office.

ELECTROLYSIS.

The investigations relating to injury to the water pipes in the Metropolitan Water District caused by electrolytic action have been continued during the year. The pipes have been examined at several points to determine the extent of the injury being done, and 27 gaging stations have been established and measurements made of the amount of electricity flowing on pipes. The results of the studies and investigations made during the past five years have already been submitted to the Board in a special report.

CLINTON SEWERAGE.

The works have been in daily operation during the whole year. The amount of sewage pumped and filtered has been fully one-third more than during the previous year, the increase being due partly to the greater amount of the ground water caused by greater rainfall, and partly to the construction of a very leaky piece of 12-inch vitrified pipe sewer by the town of Clinton, which was connected with the sewerage system early in September, and, at the request of the Board, cut off on November 30, 1901, pending reconstruction. There was a flow of water from this sewer of about 200,000 gallons per day before any house connection had been made.

The regular force has been one engineer at the pumping station and two attendants at the filter-beds, one of the latter assisting the engineer for a short time each morning. When additional help is required, the force employed on the Wachusett Aqueduct is transferred temporarily.

During the evening of March 23 there was a fire at the pumping station, caused probably by spontaneous combustion, which burned a partition and scorched the ceiling of the engine room, but did no harm to the pumping machinery.

Following are statistics relating to the operation of this station: —

Daily average quantity of sewage pumped (gallons),	838,000
Daily average quantity of coal consumed (pounds),	1,224
Gallons pumped per pound of coal,	684
Number of days pumping,	365
Cost of pumping: —	
Labor,	$1,159 01
Fuel,	995 64
Repairs and small supplies,	365 84
Total for station,	$2,520 49
Cost per million gallons pumped,	$8 24
Cost per million gallons raised 1 foot high,	18

Filter-beds.

During the warmer part of the year the sewage has been applied in about equal quantity to the 19 beds from which all soil had been removed and to the 6 beds from which the soil was not removed, each being used on the average about once in six days. During the colder part of the year only 19 beds from which the soil had been removed were used, and 5 of these beds were furrowed 3 feet 6 inches apart, for use in very cold weather.

As was the case in 1900, the results obtained in 1901 were better in the last half of the year than in the first, as will be seen by the following results of chemical analyses: —

[Parts per 100,000.]

	January to June, inclusive.	July to December, inclusive.	Whole Year.
Albuminoid ammonia, sewage,	.9250	1.0800	1.0025
Albuminoid ammonia, effluent,	.1027	.0454	.0741
Per cent. removed,	87	96	91
Oxygen consumed, sewage,	10.05	11.40	10.73
Oxygen consumed, effluent,	1.06	.58	.82
Per cent. removed,	87	95	91

The sewage treated during 1901 has been much more dilute than during the previous year, and, while the percentage of organic matter removed has not been quite as large, the effluent has been much better. The nitrification has also been better in 1901, especially during the last half of the year. The nitrification during the second half of the year continues much better than during the first half, as is shown by the following statement of free ammonia and nitrates : —

[Parts per 100,000.]

	January to June, inclusive.	July to December, inclusive.
Free ammonia, sewage,	3.0400	3.8667
Free ammonia, effluent,	.9058	.2525
Per cent. removed,	70	93
Nitrogen as nitrates, effluent,	.5383	1.3213

The cost of maintaining the filter-beds has been as follows : —

Labor,	$2,431 51
Repairs and supplies,	103 34
Total,	$2,534 85
Cost per million gallons filtered,	8 29

Appended to this report are tables of contracts giving the amount of work done and other information, a statement of the cement tests, a long series of tables relating to the maintenance of the Metropolitan Water Works, tables showing the length of main pipes and number of service pipes, meters and fire hydrants in the Metropolitan Water District, and a summary of statistics for 1901.

Respectfully submitted,

FREDERIC P. STEARNS,
Chief Engineer.

BOSTON, December 31, 1901.

REPORT OF ENGINEER OF SEWERAGE WORKS.

To the Metropolitan Water and Sewerage Board.

GENTLEMEN : — The following is a report of the operations of the Engineering Department of the Metropolitan Sewerage Works for the fifteen months' period ending December 31, 1901.

ORGANIZATION.

The engineering organization is as follows : —

Division Engineers : —

FREDERICK D. SMITH, .	In charge of maintenance, South Metropolitan System, and construction of high-level sewer, sections 51 to 63, inclusive, in Quincy and Milton.
C. BARTON PRATT, .	In charge of construction, high-level sewer, north of Neponset River.
FRANCIS L. SELLEW, .	In charge of construction, high-level sewer, sections 47 to 50, inclusive, in Quincy.
FRANK I. CAPEN, . .	In charge of maintenance and of day-work and contract construction, North Metropolitan System.
FRANK T. DANIELS, .	In charge of draughting rooms.

Assistant Engineers : —

FRANK A. EMERY, . .	Office assistant in charge of records.
JOHN S. HODGSON, .	In charge of special studies.

Stenographer : —

HENRY P. FIELDING, .	In charge of classification of engineering reports, claims and correspondence.

In addition to the above, there are employed at this date 87 engineering and other assistants.

METROPOLITAN SEWERAGE DISTRICTS.

Areas and Development.

In the period covered by this report, no legislative enactments have modified the extent or classification of areas comprising the Metropolitan sewerage districts. The North district, lying wholly north of the Charles River, has an area of 85 square miles; the South district, comprising cities and towns south of the Charles River, with Watertown and Waltham on the north, has an area of 102 square miles; making a total, inclusive of water surfaces, of 187 square miles for the two Metropolitan sewerage districts, as outlined on the general map accompanying this report.

The development of this area from the original district created by chapter 439 of the Acts of 1889 is briefly summarized in the following table: —

Table showing the Development of the Metropolitan Sewerage System, 1889 to 1901, inclusive, with the Legislative Acts referring thereto.

	CITIES AND TOWNS INCLUDED IN AREA.	Area provided for (Square Miles).		Number and Date of Act.
North Metropolitan District.	Original North Metropolitan District, including Arlington, Belmont, Boston (portions of), Cambridge, Chelsea, Everett, Malden, Medford, Melrose, Somerville, Stoneham, Winchester, Winthrop and Woburn.	71.88		Chapter 439, Acts of 1889.
	Wakefield (Greenwood and Boyntonville), . .	.95		Chapter 414, Acts of 1896.
	Lexington (part of), ...	5.11		Chapter 520, Acts of 1897.
	Wakefield (central village, etc.), ...	6.70		Chapter 172, Acts of 1900.
	Total area of North Metropolitan District, . .		84.64	
South Metropolitan District.	Original Charles River District, including Boston (portions of), Brookline, Newton, Waltham and Watertown.	42.00		Chapter 439, Acts of 1899.
	Neponset valley district, including Boston (portions of), Dedham (part of), Hyde Park and Milton.	39.57		Chapter 406, Acts of 1895.
	High-level sewer: Boston (portions of) and Quincy,	20.98		Chapter 424, Acts of 1899.
	Total area of South Metropolitan District, . .		102.55	
	Total area of Metropolitan Sewerage District, December 31, 1901, ...		187.19	

AREAS AND POPULATIONS.

The areas and populations of the cities and towns comprising the Metropolitan Sewerage District are set forth in the following table, in which the populations are approximated from the United States decennial census of 1900: —

Table showing Areas and Estimated Populations within the Metropolitan Sewerage District, as of May 1, 1901.

	CITY OR TOWN.	Area (Square Miles).		Estimated Population.	
North Metropolitan District.	Arlington,	5.20		9,400	
	Belmont,	4.66		4,500	
	Boston (portions of),	3.45		88,900	
	Cambridge,	6.11		96,500	
	Chelsea,	2.24		35,300	
	Everett,	3.34		26,700	
	Lexington,*	5.11		2,800	
	Malden,	5.07		35,800	
	Medford,	8.35		20,100	
	Melrose,	3.78		13,600	
	Somerville,	3.96		65,600	
	Stoneham,	5.50		6,300	
	Wakefield,	7.65		9,900	
	Winchester,	5.95		7,800	
	Winthrop,	1.61		6,900	
	Woburn,	12.71		14,700	
			84.64		444,800
South Metropolitan District.	Boston (portions of),	20.92		133,100	
	Brookline,	6.81		21,800	
	Dedham,*	9.40		7,100	
	Hyde Park,	4.57		13,900	
	Milton,	12.59		7,100	
	Newton,	18.03		36,300	
	Quincy,	12.56		25,800	
	Waltham,	13.63		24,900	
	Watertown,	4.04		10,500	
			102.55		280,500
	Totals,		187.19		725,300

* Part of town.

METROPOLITAN SEWERS.

SEWERS PURCHASED.

Within the Metropolitan Sewerage District there are now 82.47 miles of Metropolitan sewers, as shown on the general map. Of this total, 8.79 miles of sewer and one pumping station located in the city of Quincy have been purchased from cities and towns of the District, as detailed in the following table: —

Table of Sewers and Appurtenances purchased to December 31, 1901.

DATE OF PURCHASE.	From whom purchased.	Size.	Length (Miles).		Cost.	Legislative Acts authorizing Purchase.
September 10, 1892,	City of Boston,	6′ 6″ diameter, 4′ 8″ twin sewer, 5′ 6″ diameter,	.332 .015 .008	.355	$59,076 00	Chapter 439, Acts of 1889, Huntington Avenue sewer.
October 3, 1893,	City of Boston,	26″ × 28″, 15″,	2.240 .547	2.787	52,637 00	Chapter 439, Acts of 1889, Mystic valley sewer.
January 22, 1898,	City of Boston,	36″ × 48″, 28″ × 42″,	.981 .260	1.241	100,000 00	Chapter 406, Acts of 1895, Neponset valley sewer.
November 21, 1896,	Town of Melrose,	24″, 20″, 18″, 15″,	.154 .005 .512 .065	.736	15,000 00	Chapter 414, Acts of 1896, South Wakefield extension.
December 31, 1898,	Town of Arlington,	18″, 15″, 12″,	.999 .115 1.517	2.631	42,400 13	Chapter 520, Acts of 1897, Lexington extension.
October 8, 1898,	City of Malden,	36″, 30″, 18″,	.601 .181 .206	.988	50,096 51	Chapter 215, Acts of 1898, Everett outlet sewers.
August 6, 1900,	Town of Watertown,	24″, 12″,	.002 .049	.051	10,912 00	Chapter 464, Acts of 1900, Watertown siphon.
April 1, 1901,	City of Quincy,	Pumping station,		-	97,384 46	Chapter 424, Acts of 1899, high-level sewer.
Total,				8.789	$428,106 10	

SEWERS CONSTRUCTED AND THEIR CONNECTIONS.

The remaining 73.68 miles of Metropolitan sewer have been constructed by Metropolitan boards.

The position, lengths and sizes of these sewers are given in the following tables, which also give the public and special connections made with the system, in each city and town, under the authority of Metropolitan boards: —

North Metropolitan System.

CITY OR TOWN.	Size of Sewers.	Length in Miles.	Public Connections, December 31, 1901.	Special Connections.	
				Character or Location of Connection.	Number in Operation.
Boston: —					
Deer Island, .	6' 3" to 9', ...	1.367	2	- -	-
East Boston, .	9' to 1', ...	5.467	16	- -	-
Charlestown, .	6' 7"×7' 5" to 1', . .	3.292	11	Navy Yard, ... Almshouse, ...	5
Winthrop, . .	9', ...	2.864	6	Club house, ...	1
Chelsea, . .	8' 4"×9' 2" to 1' 10"×2' 4",	3.787	5	Bakery, ... Rendering works, . . Metropolitan Water Works blow-off.	3
Everett, . .	8' 2"×8' 10" to 4' 8"×5' 1",	2.925	4	Metropolitan Water Works blow-off.	1
Malden, . .	3' 9"×4' 1" to 1' 3", . .	3.931*	23	Metropolitan Water Works blow-off. Private houses, . . .	1 95
Melrose, . .	1' 10"×2' 9" to 10", . .	6.099†	28	Private houses, . . .	93
Cambridge, .	5' 2"×5' 9" to 1' 3", . .	5.963	19	Slaughter house, . . City Hospital, . . .	2
Somerville, . .	6' 5"×7' 2" to 1' 10"×2' 3",	3.471	9	Slaughter houses (3), . .	1
Medford, . .	4' 8"×5' 1" to 10", . .	5.359	17	Private houses, . . .	6
Winchester, .	2' 11"×3' 3" to 1' 3", . .	6.408	10	Tannery, ... Private house, . . .	2 1
Stoneham, . .	1' 3" to 10", ...	.010	3	- -	-
Woburn, . .	1' 10"×2' 4" to 1' 3", . .	.933	3	Glue factory, . . .	1
Arlington, . .	1' 6" to 10", ...	3.520‡	30	Private houses, . . .	71
Belmont,§ . .	- -	-	1	- -	-
Wakefield,§ .	- -	-	-	- -	-
		55.391‖	187		283

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* Includes .988 of a mile of sewer purchased from the city of Malden.

† Includes .786 of a mile of sewer purchased from the town of Melrose.

‡ Includes 2.631 miles of sewer purchased from the town of Arlington.

§ The Metropolitan sewer extends but a few feet into the towns of Belmont and Wakefield.

‖ Includes 2.787 miles of Mystic valley sewer in Medford, Winchester and Woburn, running parallel with the Metropolitan sewer.

South Metropolitan System.

CITY OR TOWN.	Size of Sewers.	Length in Miles.	Public Connections, December 31, 1901.	Special Connections.	
				Character or Location of Connection.	Number in Operation.
Boston (Back Bay).	6′ 6″ to 5′ 6″, . . .	1.500*	8	Private house, . . . Administration building, Boston Park Department, .	1 1
Boston (Brighton).	5′ 6″ to 12″, ...	3.714†	10	Abattoir, ...	3
Boston (Dorchester).	3′×4′ to 2′ 6″×2′ 7″, . .	2.870‡	6	- -	-
Boston (Roxbury).	6′ 6″×7′, 2′ 0″, . . .	.575	-	- -	-
Boston (West Roxbury).	9′ 3″×10′ 2″ to 12″, . .	6.014	3	Parental school, . . .	1
Brookline, .	5′ 6″, ...	.127	1	- -	-
Dedham, . .	4′×4′ 1″ to 3′ 9″×3′ 10″, .	2.350	-	- -	-
Hyde Park, .	10′ 7″×11′ 7″ to 4′×4′ 1″, .	4.382	10	- -	1
Milton, . .	11′×12′ to 8″, . . .	1.189	3	- -	-
Newton, . .	4′ 2″×4′ 9″ to 1′ 3″, . .	2.227	6	Private houses, . . .	2
Quincy, . .	11′ 3″×12′ 6″ to 11′×12′, .	1.378	-	- -	-
Waltham, .	3′ 6″×4′, ...	.001	1	- -	-
Watertown, .	4′ 2″×4′ 9″ to 12″, . .	.750§	5	Factory, ...	2
		27.077	53		11

* Includes .355 of a mile of sewer purchased from the city of Boston.

† Includes .026 of a mile of sewer purchased from the town of Watertown.

‡ Includes 1.24 miles of sewer purchased from the city of Boston.

§ Includes .025 of a mile of sewer purchased from the town of Watertown.

COST OF CONSTRUCTION.

The cost of the 82.47 miles of Metropolitan sewers enumerated above, including five pumping stations, siphons and appertaining structures, may be summarized as follows: *—

North Metropolitan System, ...	$5,565,707 81
South Metropolitan System, ...	3,430,229 01
	$8,995,936 82

CONSTRUCTION AND ADDITIONS SINCE SEPTEMBER 30, 1900.

The report of September 29, 1900, indicated that 71.9 miles of Metropolitan sewers had been constructed at that date. There has consequently been added, during the fifteen months under review, a length of 10.57 miles. This includes 3.04 miles in the Wakefield extension, authorized by chapter 172 of the Acts of 1900, and 1.58 miles in additional outlets for the cities of Chelsea and Everett, by chapter 184 of the same year, all in the North Metropolitan District.

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* For detailed statement of cost, see report of Board, p. 58.

In the South Metropolitan District, chapter 204 of the Acts of 1901 authorized an extension of 1.27 miles, to provide additional sewerage facilities for the city of Newton and the town of Brookline in the Neponset valley system. Of this length 0.4 mile have been constructed to date. On April 1, 1901, the pumping station of the Quincy sewerage system was purchased from that city by your Board, under the provisions of the high-level sewer act, and has since that date been operated as part of the South Metropolitan System.

The remaining length of Metropolitan sewers added during the year consists of 5.55 miles of new high-level sewer in the South Metropolitan District, authorized by chapter 424 of the Acts of 1899, and referred to in detail later in this report.

The following table gives details of areas, populations, local sewer mileage and other data for the whole Metropolitan Sewerage System: —

North Metropolitan System.

Area (Square Miles).	Estimated Total Population.	Miles of Local Sewer connected.	Estimated Population contributing Sewage.	Ratio of Contributing Population to Total Population (Per Cent.).	Connections made with Metropolitan Sewers.	
					Public.	Special.
84.64	444,900	485.81	324,333	72.9	187	283

South Metropolitan System.

102.55	280,500	344.24	110,121	39.3	53	11

Entire Metropolitan District.

187.19	725,400	830.05	434,454	59.9	240	294

Contrasting these figures with corresponding data for September 29, 1900, there is an estimated increase in population of 27,400 during the fifteen months under review. Of the estimated gross population of 725,300 on May 1, 1901, 434,454, representing 59.9 per cent., were on that date contributing sewage to the Metropolitan sewers, through a total length of 830.05 miles of local sewers owned by the individual municipalities. These sewers are connected with the Metropolitan System by 240 public and 294 special connections.

Further examination of the figures for this period of fifteen months indicates that the population contributing sewage has probably increased by 27,720; that an addition of 62.54 miles of local sewers has been made to the lengths previously connected, and that 8 public and 34 special connections have been added.

PUMPING STATIONS AND PUMPAGE.

The following table shows the average daily volume of sewage lifted at each of the five Metropolitan pumping stations during the fifteen months' period, as compared with the corresponding volumes for the previous year: —

PUMPING STATION.	AVERAGE DAILY PUMPAGE.			
	Year ending Sept. 30, 1900.	Oct. 1, 1900, to Dec. 31, 1901.	Increase during Period.	
	Gallons.	Gallons.	Gallons.	Per Cent.
Deer Island,	44,600,000	52,000,000	7,400,000	16.60
East Boston,	42,400,000	49,200,000	6,800,000	16.04
Charlestown,	27,500,000	30,700,000	3,200,000	11.64
Alewife Brook,	3,543,000	3,780,000	237,000	6.69
Quincy,	-	2,014,000	-	-

HIGH-LEVEL SEWER.

Surveys and general studies in connection with the high-level sewer have been continued during the period under review. Of the final location along the whole length, something over 16 miles, from the connection with the existing Charles River system at the intersection of Ruggles and Vancouver streets, near the Fenway, in the Back Bay district of the city of Boston, to the outlet in the harbor, within the limits of the town of Hull, about 1 mile north of Nut Island, has been completed. For convenience, this length has been divided into 36 contract sections. Of these, 4 have been completed and 23 are now in process of construction; contracts for the remaining 9 sections, representing 2.7 miles, are yet to be entered into. The engineering studies for these sections are in condition for the letting of contracts during the coming season.

CONSTRUCTION ON THE NORTH METROPOLITAN SYSTEM (OCTOBER 1, 1900, TO DECEMBER 31, 1901).

ADDITIONS TO PUMPING PLANT, ALEWIFE BROOK STATION.

Chapter 424 of the Acts of 1898 provided for additional engines and pumps at the stations of the North Metropolitan System. At Deer Island, East Boston and Charlestown the plants were installed and accepted prior to the date of the last engineering report. At the Alewife Brook station the George F. Blake Manufacturing Company, contractors for this work, have made various modifications in the plant, with the result of increasing its efficiency, but the full duty guaranteed has not yet been attained.

SEWER CONSTRUCTION IN CHELSEA AND EVERETT, AND EXTENSION TO WAKEFIELD.

The sewer construction on the North Metropolitan System consists of additional outlets for areas in Chelsea and Everett and the extension to Wakefield, respectively authorized by chapters 184 and 172 of the Acts of 1900. The total appropriation made by these acts was $265,000.

The total length of 4.6 miles included in this work was divided, for convenience, into 5 contract sections. The whole of these have been completed. Details of the work are given in a condensed form in the following table, and at greater length in the succeeding description: —

Contract Sections in Chelsea, Malden and Melrose, and Day Work connected therewith, forming Parts of the North Metropolitan System, October 1, 1900, to December 31, 1901.

Number of Contract Section.	LOCATION.	Size of Sewer.	Length (Feet).	Total Length of Section (Feet).	Date of Contract.	Date of Completion.	Cost of Work.	Total Cost of Section.	Contractor.
56	Chelsea, — Willoughby Street to Clark Avenue,	42", 33", .	2,812	-	Sept. 17, 1900,	July 1, 1901,	$38,364 17	-	H. A. Hanscom & Co., Boston, Mass.
	Day work (connection of Section 56 with existing Metropolitan sewer near Willoughby Street), ...	. . . .	75	2,887	-	June 29, 1901,	3,652 69	$42,016 86	- -
57	Chelsea, — Clark Avenue to Everett line, .	33", 30" and 22"×28", .	-	5,428	Sept. 17, 1900,	Sept. 7, 1901,	-	28,637 85	H. A. Hanscom & Co., Boston, Mass.
58	Malden and Melrose, — Barrett's Pond to Goodyear Avenue, ...	48", 54"×58",	5,379	-	Nov. 12, 1900,	Nov. 2, 1901,	59,309 90	-	Bruno, Salamone & Pettiti, Boston, Mass.
	Day work (connection of Section 58 with existing Metropolitan sewer near Barrett's Pond),	. . . .	15	5,394	-	Aug. 5, 1901,	910 10	60,220 00	- -
59	Melrose, — Goodyear Avenue to near Willow Street, ...	54"×58", 36",	4,779	-	Nov. 12, 1900,	Oct. 16, 1901,	56,500 02	-	Chas. G. Belden & Co., Syracuse, N. Y.
	Day work (part of section near Wyoming Avenue), ...	. . . .	200	4,979	-	Oct. 26, 1901,	7,261 90	63,761 92	- -
60	Melrose, — between Willow Street and Wakefield line, first contract, ...	36", . .	1,186	-	Nov. 12, 1900,	May 18, 1901,	12,204 67	-	Old Colony Construction Company, Boston, Mass.
	Day work (unfinished portion of first contract),	. . . .	170	-	-	-	4,276 71	-	- -
	Second contract, remainder of section, . .	36" and 30", .	4,339	5,695	June 29, 1901,	Dec. 3, 1901,	47,303 54	63,784 92	Metropolitan Contracting Company, Boston, Mass.
	Totals, ...	. . . .	. .	24,383				$258,421 55	

ADDITIONAL OUTLETS, IN CHELSEA AND EVERETT.

Section 56, Chelsea.

Location. **— From near the junction of Eastern Avenue and Willoughby Street, extending northerly through Eastern Avenue and Cabot Street to near the westerly line of Clark Avenue.**

Division Engineer in Charge. **— Frank I. Capen.**

Contractor. **— H. A. Hanscom & Co. of Boston.**

Length (Feet).	Size.	Average Cut (Feet).	Maximum Cut (Feet).
2,645	42-inch circular, ...	16.70	24.8
242	33-inch circular, ...	19.50	23.3
2,887			

Total cost, ... $42,016.86

Excavation was begun September 25, 1900. The average rate of progress was 72 feet per week, with a maximum of 181 feet. The work was completed July 1, 1901. The work was generally in open trench. A length of 90 feet, under Broadway, was in tunnel. About 1,800 feet at the lower end, built on a pile foundation, was in fine silt, overlaid with from 4 to 6 feet of fibrous peat below filling and road surfacing. Only a small amount of water was found in the trenches. The excavation in the remainder of the section was in clay and hard-pan.

This contract section was connected with the existing Metropolitan sewer by 75 feet of sewer carried under the existing city sewer in Willoughby Street. Two parallel lengths of 20-inch cast-iron pipe were used for the sewer crossing. The whole length is on a pile foundation, and was constructed by day labor, at a total cost of $3,652.69.

Section 57, Chelsea.

Location. **— From near the westerly line of Clark Avenue, westerly through private land and the Metropolitan Park Reservation to Garfield Avenue; thence through Bell Street and Springvale Avenue to the boundary line between Chelsea and Everett.**

Division Engineer in Charge. **— Frank I. Capen.**

Contractor. **— H. A. Hanscom & Co. of Boston.**

Length (Feet).	Size.	Average Cut (Feet).	Maximum Cut (Feet).
1,653	33-inch circular, ...	8.00	8.00
651	30-inch circular, ...	7.00	7.00
3,122	22-inch by 28-inch Gothic, ...	11.75	23.20
5,426			

Total cost, ... $28,637.85

Excavation was begun September 27, 1900. The average rate of progress was 111 feet per week, with a maximum of 322 feet. The work was completed September 7, 1901. The excavation was wholly in open trench, and for a length of 2,900 feet from Clark Avenue, passing through the marshes near Mill Creek, was in hard blue clay, overlaid with from 2 to 4 feet of peat. The remainder of the section was in hard-pan, sand and gravel. But little water was found in the trenches, except for about 200 feet adjoining the Everett line, where the flow from springs required the use of a pulsometer pump.

EXTENSION TO WAKEFIELD.

Section 58, Malden and Melrose.

Location. — **From junction with existing Metropolitan sewer in private land, near Barrett's Pond, in Malden, northerly through private land, Linden Avenue, Clinton Street and land of the Boston & Maine Railroad to near the southerly side of Goodyear Avenue, in Melrose.**

Division Engineer in Charge. — **Frank I. Capen.**

Contractor. — **Bruno, Salomone & Pettiti of Boston.**

Length (Feet).	Size.	Average Cut (Feet).	Maximum Cut (Feet).
2,665	48-inch circular, ...	16.2	23.0
2,729	54-inch by 58-inch oval, ...	9.6	13.0
5,394			

Total cost, ... $60,220.00

Excavation was begun on December 11, 1900. The entire section was completed on November 2, 1901. The average rate of progress of excavation was 120 feet per week, with a maximum of 287 feet.

A bell-mouth structure was built at Linden Avenue, near station 2+00, to provide for a southerly extension of the sewer at a future date.

The 48-inch sewer was carried over the existing Metropolitan sewer, near Oak Grove station, by 24 feet of 48-inch cast-iron pipe. Above this crossing the sewer is 54 inches by 58 inches in diameter. At the crossing of Spot Pond Brook, near Fells station, 42-inch cast-iron pipes are used.

Near the lower end the excavation was in gravel, boulders and rock; the remainder was in fine sand.

Surplus earth from the trench was used to form an embankment over the sewer in the Boston & Maine Railroad land, and for filling land adjacent to other parts of the work.

This contract section was connected with the existing Metropolitan sewer by 15 feet of sewer, consisting of bell-mouth structure and entrance man-hole, near Barrett's Pond. This work was constructed by day labor, at a total cost of $910.10.

Section 59, Melrose.

Location. — **From near the southerly side of Goodyear Avenue, northerly through location of Boston & Maine Railroad to Foster Street; thence through private land to a point in Essex Street, about 170 feet west of Willow Street.**

Division Engineer in Charge. — **Frank I. Capen.**

Contractor. — **Charles G. Belden & Co. of Syracuse, N. Y.**

Length (Feet).	Size.	Average Cut (Feet).	Maximum Cut (Feet).
3,200	54-inch by 58-inch oval, ...	11.9	16.5
1,779	36-inch circular, ...	15.9	18.0
4,979			

Total cost, ... $63,761.92

Excavation was begun on December 3, 1900, and the contract work was completed on October 16, 1901. The average progress of earth excavation was 112 feet per week, with a maximum of 315 feet.

The excavation was generally in fine sand, with occasional lengths of gravel and clay and a small amount of rock.

Surplus material from the trench was used by the Boston & Maine Railroad for grading along its right of way.

Near Wyoming station the sewer passes under the existing Metropolitan sewer and the Ell Pond Brook culvert, and is also close to the foundations of a business block. A length of 200 feet was omitted in the contract section at this point, and this portion of the work was completed later by day labor, at a total cost of $7,261.90. It consists principally of brick sewer, with connection chambers at the junction with the original Metropolitan sewer. Twenty-four feet of 54-inch cast-iron pipe, reinforced with concrete, were used in passing the Ell Pond Brook culvert.

Section 60, Melrose.

Location. — From a point in Essex Street, about 170 feet west of Willow Street, northerly through Essex, Tremont and Franklin streets, Winthrop Place and location of Boston & Maine Railroad to the Wakefield line.

Division Engineer in Charge. — Frank I. Capen.

Contractor. — The Old Colony Construction Company, succeeded by the Metropolitan Contracting Company, both of Boston.

Length (Feet).	Size.	Average Cut (Feet).	Maximum Cut (Feet).
2,781	36-inch circular, ...	15.0	22.0
2,914	30-inch circular, ...	14.5	19.5
5,695			

Total cost, ... $63,784.92

Of the total length, 1,425 feet of 36-inch and 2,914 feet of 30-inch sewer were built by the Metropolitan Contracting Company.

Excavation was begun by the Old Colony Construction Company on November 28, 1900, and continued until May 18, 1901, when the contract was abandoned, leaving considerable trench ready for the structures. The masonry work in these lengths of trench was built by day labor, under the direct supervision of the Engineer. Including these lengths, the work accomplished under the original contract amounted to 1,356 feet of 36-inch sewer. Bids were obtained for constructing the remainder of the section, and June 29, 1901, a contract for this work was entered into by the Metropolitan Contracting Company. Work was commenced on July 8 and advanced rapidly until its completion on December 3, 1901.

The average rate of progress under the original contract was 54 feet per week, for two openings; the average under the second contract was 206 feet per week, with three openings.

Much of the excavation was in sand and gravel, yielding considerable quantities of water and requiring heavy sheeting in the trenches. The maximum rate of pumpage was 1,000,000 gallons per twenty-four hours. For a length of 700 feet, in Tremont Street, passing the end of Ell Pond, the sewer was built on a pile foundation; in two lengths of 300 and 350 feet, respectively, the bottom of the trench was in rock.

The day work included the refilling of 240 feet of sewer trench abandoned by the Old Colony Construction Company, the comple-

tion and refilling of 150 feet of partly excavated trench, the building of 170 feet of brick sewer, and the subsequent resurfacing of streets. The total cost of work done by day labor was $4,276.71.

This section terminates at the Wakefield line, and provides for the connection at that point of the system of sewers now being constructed by that town.

CONSTRUCTION ON THE SOUTH METROPOLITAN SYSTEM (October 1, 1900, to December 31, 1901).

This construction consists of the Neponset valley sewer extension, authorized by chapter 254 of the Acts of 1901, and of the high-level sewer by chapter 424 of the Acts of 1899, which has been under construction since November of that year.

Neponset Valley Sewer, West Roxbury and Newton.

Section 30.

Division Engineer in Charge. — C. Barton Pratt.
Contractor. — Thomas J. Kelley, Brookline, Mass.

This contract embraces the construction of brick and pipe sewers extending from the existing Neponset Valley sewer, in St. Joseph's Cemetery, West Roxbury, through the cemetery and other private lands in West Roxbury and Newton, to the Brookline town line, midway between Newton and La Grange streets, — a total distance of 6,718 feet. Of this length, 2,356 feet is to be 24-inch brick sewer, and the remainder 18-inch and 15-inch pipe sewers. The route follows generally the brook valleys, and the excavation is in sand, gravel and sandy clay, with an average depth of 9 feet. A small amount of rock has been found in the excavation. During winter storms the trenches through the valleys have been flooded and the work has been delayed by this cause. About 1,800 feet of sewer has been constructed to date.

Quincy Pumping Station.

On April 1, 1901, the sewage pumping station of the city of Quincy was purchased by the Commonwealth, as contemplated by the high-level sewer act. The pumping station and plant consist of a one-story brick building, 85 by 45 feet, with a heavy slated roof, erected in 1897–98; two Deane pumps, with boilers and all other necessary appurtenances, having a capacity of 3,000,000 and 5,000,000 gallons per day, respectively; and about 2¾ acres of land, — the whole located near the northerly limit of the city park known as Merrymount Park. The purchase includes a 24-inch cast-iron force main from the pumping station to its junction with the outfall sewer of the Boston main drainage system, at Squantum, a distance of about 3.4 miles, together with all rights and easements in relation thereto acquired by the city of Quincy. The price paid for the works was $97,984.46.

The pumping plant has been operated by this department, as part of the South Metropolitan Sewerage System, since April 1, 1901. The sewage is still pumped into the Boston main drainage system, at Squantum, but on the completion of the high-level sewer it will be pumped into that structure, in Greenleaf Street, through a new force main, when the connection with the Boston works will be abandoned.

HIGH-LEVEL SEWER CONSTRUCTION.

Route of High-level Sewer.

Prior to September 29, 1900, construction on the high-level sewer had been confined to that portion, about 6½ miles in length, located north of the Neponset River. The route of the sewer, extending from the proposed pumping station in Ward Street, Roxbury, to the Neponset River, was fully described in the twelfth annual report of the Metropolitan Sewerage Commissioners. The sewer will be carried under the Neponset River by three parallel lines of 60-inch cast-iron pipe, connected on each bank with the ordinary sewer structures by masonry pipe chambers, arranged for controlling or diverting the flow through the individual pipe lines.

South of the Neponset River, the sewer, 10 feet 7 inches by 11 feet 7 inches in diameter, will pass through private land and across Brush Hill Road and Blue Hill Avenue to Brook Road, in Milton. It will follow Brook Road, partly in open cut and partly in tunnel, to and under Pine Tree Brook. From this point, across Central Avenue to Adams Street, in Milton, a distance of about 11,400 feet, the route will be along the lines of a boulevard extension as laid out by the town of Milton. The sewer will follow Adams Street in open cut, crossing the New York, New Haven & Hartford Railroad

(Granite Branch), to near Church Street, where its size will be increased to 11 feet by 12 feet. From this point it will pass in rock and earth tunnel along Adams Street and across the Quincy line to Eaton's Pond, on Furnace Brook, where the vertical diameter will be increased to 12 feet 3 inches. It will continue, in a northeasterly direction, along the location of the proposed Metropolitan Furnace Brook Parkway and through private lands on the southerly side of Furnace Brook, to Adams Street, in Quincy. It will extend thence, generally in an easterly direction, through Adams Street, Upland Road and private lands, partly in tunnel, to Hancock Street, where its dimensions will be increased to 11 feet 3 inches by 12 feet 6 inches. It will continue through Greenleaf Street and in private lands near Mount Wollaston Cemetery to Sea Street, which it will traverse for about 2,000 feet before entering Quincy marsh. Its course will then lie in the marsh for a distance of about 9,400 feet, nearly all in embankment, to the junction of Sea and Darrow streets, in Quincy. From this point the line follows Sea and Ratchford streets and private lands to the shore of Quincy Bay. The sewer will be carried, in a short embankment, across an angle of the bay and through private lands to a tunnel in Island Avenue, Hough's Neck, passing under Quincy Great Hill, emerging at the upper end of an embankment which will connect Nut Island with the mainland. On Nut Island there will be special structures for intercepting sand and floating matter before the sewage enters the sea outfalls. The latter will consist of 60-inch cast-iron pipes, laid in dredged trenches in the harbor bed, and carried to points about a mile beyond low-water line of Nut Island.

It is proposed to lay two such lines in the early future, and to make provision for connecting additional lines, as required.

For purposes of construction the high-level sewer has been divided into 36 contract sections, of which 14 are north of and 22 south of the Neponset River. Particulars of these sections are condensed in the following table: —

Details of Contract Sections, High-level Sewer.

Number of Contract Section.	LOCATION.	Size of Sewer.	Total Length of Section (Feet).	Estimated Length in Trench (Feet).	Estimated Length in Tunnel.		Date of Contract.	Date named for Completion.	Amount of Contract.	Estimated Value of Work completed to Dec. 31, 1901.	Contractor.
					Earth (Feet).	Rock (Feet).					
43	Quincy and Hull, — harbor outfalls.	Two 60-inch pipes.	5,694*	5,694	-	-	-	-	-	-	- -
44	Quincy, — Nut Island and Hough's Neck.	11' 3"×12' 6",	1,285	1,285	-	-	-	-	-	-	- -
45	Quincy, — Island Avenue, Hough's Neck.	11' 3"×12' 6",	918	-	918	-	-	-	-	-	- -
46	Quincy, — private land and flats.	11' 3"×12' 6",	823	823	-	-	-	-	-	-	- -
47	Quincy, — private land, Ratchford and Sea streets.	11' 3"×12' 6",	3,162	3,162	-	-	Oct. 3, 1901,	Jan. 1, 1903,	$95,796 28	$8,550 00	Chas. G. Belden & Co., Quincy, Mass.
48, 49	Culverts and embankments.	-	-	-	-	-	May 23, 1901,	Feb. 1, 1902,	70,175 00	25,000 00	Chas. G. Belden & Co., Quincy, Mass.
48	Quincy, — private lands, .	11' 3"×12' 6",	5,881	5,881	-	-	-	-	-	-	- -
49	Quincy, — private lands, .	11' 3"×12' 6",	3,494†	3,494	-	-	May 23, 1901,	Feb. 1, 1902,	69,350 00	63,920 00	Chas. G. Belden & Co., Quincy, Mass.
50	Quincy, — Sea Street and private lands.	11' 3"×12' 6",	3,071	3,071	-	-	Oct. 3, 1901,	Dec. 1, 1902,	94,168 80	12,950 00	Chas. G. Belden & Co., Quincy, Mass.
51	Quincy, — Greenleaf Street,	11' 3"×12' 6",	2,366	2,366	-	-	Jan. 19, 1901,	Mar. 1, 1902,	79,695 70	66,100 00	Thos. F. Moore, Syracuse, N. Y.
52	Quincy, — private lands, Upland Road and Adams Street.	11' 0"×12' 3",	2,774	2,567	207	-	Oct. 1, 1901,	Jan. 1, 1903,	167,376 30	11,180 00	National Contracting Company, New York, N. Y.
53	Quincy, — Adams Street, private lands and Furnace Brook Parkway location.	11' 0"×12' 3",	1,900	1,900	-	-	Oct. 1, 1901,	Jan. 1, 1903,	99,502 00	5,180 00	National Contracting Company, New York, N. Y.
54	Quincy, — Furnace Brook Parkway location and Adams Street.	11' 0"×12' 3",	1,990	1,990	-	-	Oct. 1, 1901,	Jan. 1, 1903,	93,936 00	4,580 00	National Contracting Company, New York, N. Y.
55	Quincy and Milton, — Adams Street.	11' 0"×12' 0",	3,555	400	1,555	1,600	Nov. 26, 1900,	June 1, 1902,	239,800 00	104,100 00	H. P. Nawn, Boston, Mass.

* Mean of two lines.

† 2,000 feet of sewer included in contract.

Details of Contract Sections, High-level Sewer — Concluded.

Number of Contract Section.	LOCATION.	Size of Sewer.	Total Length of Section (Feet).	Estimated Length in Trench (Feet).	Estimated Length in Tunnel. Earth (Feet).	Estimated Length in Tunnel. Rock (Feet).	Date of Contract.	Date named for Completion.	Amount of Contract.	Estimated Value of Work completed to Dec. 31, 1901.	Contractor.
56	Milton, — Adams Street, .	10' 7"×11' 7",	1,495	1,495	-	-	Nov. 26, 1900,	Nov. 1, 1901,	$86,050 00	$91,100 00	National Contracting Company, New York, N. Y.
57	Milton, — boulevard location, Adams Street to Pleasant Street.	10' 7"×11' 7",	1,874	1,874	-	-	Oct. 23, 1901,	Jan. 1, 1903,	58,840 00	7,990 00	J. W. Bustin & Co., Syracuse, N. Y.
58	Milton, — boulevard location, Pleasant Street to Centre Street.	10' 7"×11' 7",	2,560	2,560	-	-	Oct. 12, 1901,	Apr. 1, 1903,	81,097 00	900 00	Latta & Terry Company, Philadelphia, Pa.
59	Milton, — boulevard location, Centre Street to Randolph Avenue.	10' 7"×11' 7",	2,567	2,567	-	-	Oct. 8, 1901,	Apr. 1, 1903,	100,116 00	6,100 00	H. P. Nawn, Boston, Mass.
60	Milton, — boulevard location, Randolph Avenue to Canton Avenue.	10' 7"×11' 7",	1,609	1,609	-	-	Oct. 23, 1901,	Jan. 1, 1903,	58,452 50	-	J. W. Bustin & Co, Syracuse, N. Y.
61	Milton, — Brook Road, or boulevard extension.	10' 7"×11' 7",	2,800	2,800	-	-	-	-	-	-	-
62	Milton, — Brook Road, westerly from Pine Tree Brook.	10' 7"×11' 7",	2,174	1,778	-	396	Nov. 17, 1900,	Nov. 1, 1901,	112,750 00	107,300 00	E. W. Everson & Co., Providence, R. I.
63	Milton, — Brook Road and private land to near Neponset River.	10' 7"×11' 7",	2,262	2,262	-	-	Nov. 26, 1900,	Nov. 1, 1901,	103,875 00	86,500 00	National Contracting Company, New York, N. Y.
64	Milton and Hyde Park, — Neponset River crossing.	Three 60-inch pipes, etc.	272	272	-	-	-	-	-	-	-
65	Hyde Park, — Monponset, River and Baldwin streets.	10' 7"×11' 7", 9' 8"×10' 2".	900	900	-	-	Oct. 13, 1899,	Apr. 12, 1901,*	38,610 00	34,100 00	Beckwith & Quackenbush, Mohawk, N. Y.
66	Hyde Park, — Baldwin Street, Ruskin Road, private land.	9' 8"×10' 2", .	5,300	-	-	5,300	Oct. 13, 1899,	Oct. 1, 1901,	215,600 00	123,620 00	Ed. W. & John J. Everson, Providence, R. I.

67	Hyde Park, — Stony Brook crossing, private land.	9' 3"×10' 2", two 60-inch pipes.	327	327	-	-	†	-	21,000 00‡	4,000 00	Day labor.
68	Hyde Park and West Roxbury, — private land, Ashland Street, Hadwin Way.	9' 3"×10' 2", 8' 9"×9' 8".	2,738	2,698	40	-	Oct. 13, 1899,	Dec. 8, 1900,*	68,843 00	71,030 00	Beckwith & Quackenbush, Mohawk, N. Y.
69	West Roxbury, — Hyde Park Avenue.	8' 9"×9' 8", .	2,596	2,596	-	-	Oct. 13, 1899,	July 1, 1901,*	86,125 00	92,820 00	Beckwith & Quackenbush, Mohawk, N. Y.
70	West Roxbury, — Larch Place, private land, South Street.	8' 9"×9' 8", .	3,740	3,740	-	-	Apr. 14, 1900,	Dec. 1, 1901,	89,492 00	89,870 00	Chas. Linehan, Cambridge, Mass.
71	West Roxbury, — South Street, private land.	8' 9"×9' 8", .	2,193	2,005	188	-	Apr. 14, 1900,	July 19, 1901,*	70,100 00	84,140 00	Chas. F. Taylor & Co., Syracuse, N. Y.
72	West Roxbury, — South Street.	8' 9"×9' 8", .	3,010	1,870	1,140	-	Sept. 29, 1900,	July 1, 1901,	103,101 00	107,480 00	Jones & Meehan, Boston, Mass.
73	West Roxbury, — South and Centre streets.	9' diameter, .	4,775	-	3,375	1,400	Nov. 3, 1900,	Jan. 1, 1903,	236,425 00	36,550 00	National Contracting Company, New York, N. Y.
74	West Roxbury and Roxbury, — Centre and Day streets.	8' 3"×9' 2", 6' 6"×7' 0"	2,985	200	-	2,785	Sept. 17, 1900,	Oct. 1, 1902,	129,965 00	116,900 00	H. P. Nawn, Boston, Mass.
75	Roxbury, — private land, St. Alphonsus Street.	6' 6"×7' 0", .	3,070	-	-	3,070	Oct. 11, 1901,	Nov. 1, 1902,	117,000 00	31,460 00	Shailer & Schniglau Company, Chicago, Ill. (part of); Ed. W. & John J. Everson, Providence, R. I. (remainder).
76	Roxbury, — St. Alphonsus, Ward, Smith, Oregon, Conant and Phillips streets.	48-inch pipe (force mains).	1,490§	1,490	-	-	-	-	-	-	- -
77	Roxbury, — Ward Street pumping station and connections.	-	420	420	-	-	-	-	-	-	- -
78	Roxbury, — Vancouver Street; pumping station to Charles River sewer.	6' 6"×7' 0", .	700	700	-	-	-	-	-	-	- -
	Totals, ...	. . .	88,770	66,796	7,423	14,551	-	-	$2,782,241 58	$1,393,420 00	

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* Date of actual completion. † Now in course of construction by Engineering Department. ‡ Estimated cost. § Mean of two lines.

This table indicates that, out of a total length of 16.81 miles of high-level sewer, 14.08 miles have been contracted for. Of this length, 7.24 miles are excavated to grade in trench or tunnel, leaving 6.84 miles at a less advanced stage of construction and 2.73 miles yet to be advertised. The total value of work already under contract is $2,782,241, of which work valued at $1,393,420, representing 50 per cent., has been constructed to date.

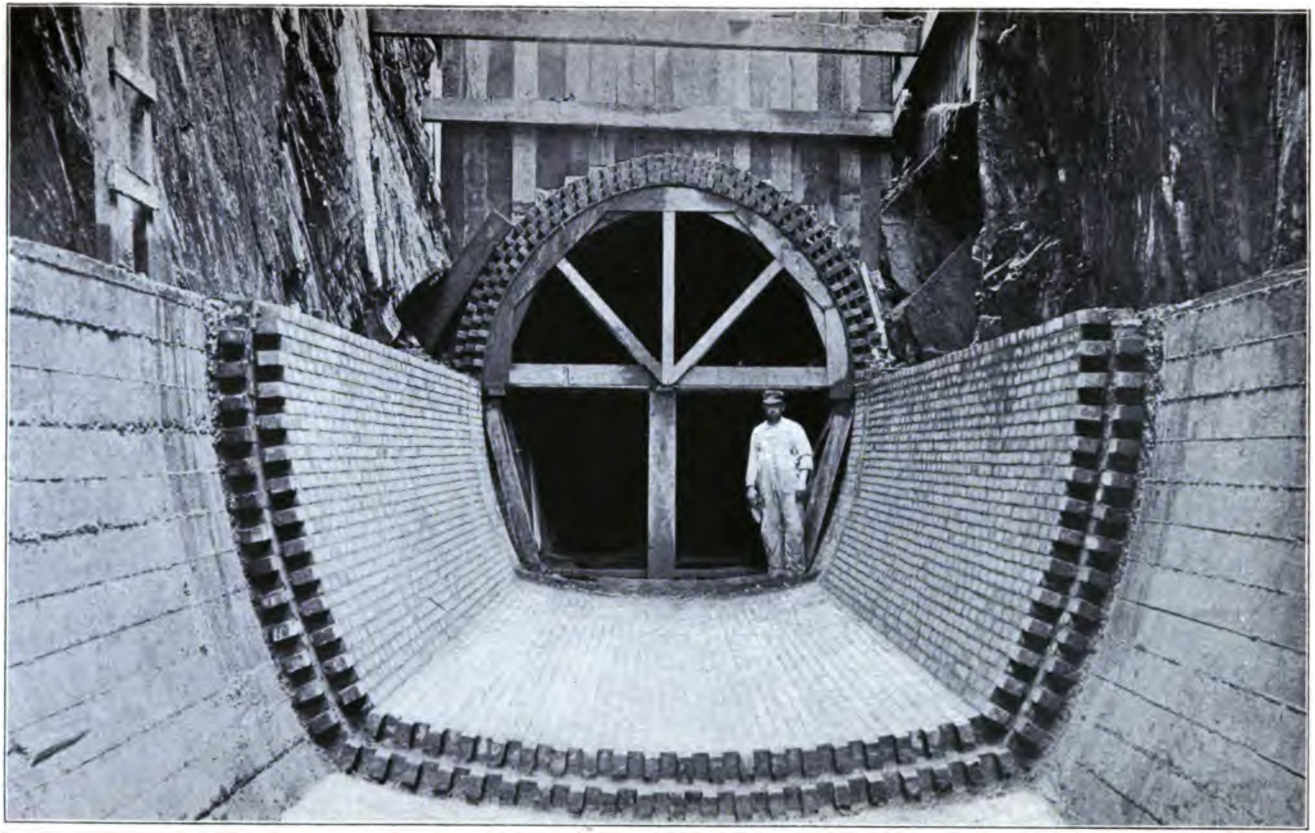
The table shows further that 12.65 miles of the total length of high-level sewer are designed to be constructed in open trench, the remaining 4.16 miles being in tunnel. The latter portion of the work is estimated as consisting of 1.41 miles of earth tunnel and 2.75 miles of rock tunnel.

During the period covered by the present report approximately 75,000 cubic yards of rock have been excavated in tunnel and in open cut. About 90 tons of dynamite or other explosives have been used.

Type of High-level Sewer.

With the exception of Section 73, in which constructional reasons dictated a circular cross-section, the high-level sewer is of the horseshoe type, in which the horizontal diameter closely approximates nine-tenths of the vertical. The arch is slightly pointed. The usual construction consists of concrete invert and side walls, lined with brickwork in cement. Where the work is under any considerable head of ground water, two rings of brickwork, aggregating 8 inches in thickness, are used in the invert and side walls. In dry ground a single ring of brickwork is used. The inner ring is in all cases built in Portland cement mortar. The brick arch is usually 12 inches thick, and is generally built in Rosendale natural cement mortar. In the 6 feet 6 inches by 7 feet sewer above the bell-mouth structure at Perkins Street (sections 74 and 75) the brickwork of the arch is 8 inches thick. In favorable ground Rosendale cement is used for concrete for the outer brickwork ring of the invert and for the arch; but Portland cement is substituted, both for brickwork and concrete, to meet such conditions as the presence of water in the bottom or sides of the trench, for construction in embankment, etc.

The following brief description refers only to sections wholly or partly constructed, or upon which liabilities have been incurred.



HIGH LEVEL SEWER—CONSTRUCTION IN OPEN CUT THROUGH ROCK, IN ADAMS STREET, EAST MILTON.

Section 43, Quincy and Hull.

This comprises the 60-inch cast-iron outfalls extending from near the shore of Nut Island to points 1 mile beyond low-water line. The pipes will be laid in a trench dredged in the bed of the harbor. Two lines, respectively 5,555 and 5,833 feet long, are contemplated at present. A contract has been entered into with the United States Cast-iron Pipe and Foundry Company for 2,920 tons of 60-inch straight pipe and 70 tons of 60-inch specials required for the longer line. These are to be delivered on Barker's Wharf, Quincy Point, between April 1 and November 1, 1902, so as to be available for placing in the harbor during the coming season.

Section 47, Quincy.

Division Engineer in Charge. — **Francis L. Sellew.**
Contractor. — **Charles G. Belden & Co., Syracuse, N. Y.**

The sewer is 11 feet 3 inches by 12 feet 6 inches in diameter and 3,162 feet in length. It extends from Prospect Avenue, through private land, Ratchford and Sea streets to the intersection of the latter with Darrow Street. The excavation, in dry sand and gravel, has an average depth of about 20 feet. For a length of about 300 feet near Winthrop Street the construction is partly in embankment. At the upper end of the section, near Darrow Street, the grade of Sea Street is to be raised about 4 feet, to afford a sufficient depth of cover over the sewer arch.

Excavation was commenced on Sea Street, near Manet Avenue, on October 31, 1901. To avoid interference with summer travel to Hough's Neck, the construction on Sea Street, east of Manet Avenue, is being carried on during the winter months. About 300 feet of sewer have been completed to date.

Culverts and Embankments, Sections 48–49, Quincy.

Division Engineer in Charge. — **Francis L. Sellew.**
Contractor. — **Charles G. Belden & Co., Syracuse, N. Y.**

Sections 48 and 49 have a total length of 9,375 feet, extending from the intersection of Sea and Darrow streets through private and marsh lands, in a westerly direction, generally parallel to Sea Street, to a point on the upland about 35 feet southeasterly from Sea Street, near the Adams homestead. For a length of 8,200 feet the elevation of the ground is such as to involve the construction of the sewer in embankment. The top of the finished embankments will be 3 feet above the outside of the sewer arch and 19 feet above marsh level; it will be 25 feet in width, and slopes of 2 horizontal to 1 vertical will give a bottom width of 100 feet. Where exposed to wash from floods or tide, the slopes will be protected by stone riprap up to an elevation of 18 feet above mean low water. Above this elevation the slopes will be dressed with loam or vegetable mould from the marsh excavations.

This contract includes the construction of embankments, to subgrade, for the whole length of Section 48, or 5,881 feet, and for about 1,200 feet of Section 49. The remaining length of embankment on Section 49, about 1,000 feet, is included in other contracts.

Important areas of marsh and other lands will be enclosed between the embankment and Sea Street, thus impounding drainage water otherwise flowing to the sea across the sewer location. To provide outlets for this water, masonry culverts are built through the embankments under the location of the sewer structure. These will have cut-stone faces and coursed ashlar inlets and outlets. Culverts on Section 48 are included in this contract, as detailed in the following table: —

Culverts, Section 48.

LOCATION.	Cross-section.	Length (Feet).	Length over All (Feet).	Details of Construction.
Near Malvern Road, Station 9 + 70.	4′ 0″ circular,	77	94	Concrete, with brick lining; 2 12-foot lengths of cast-iron pipe immediately under sewer structure.
Near Newton Street, Station 17 + 95.	4′ 0″ circular,	79	97	
Rock Island Road, Station 37 + 65.	9′ 6″ × 4′ 6″ (double).	100	110	Concrete, with brick lining; 12-inch steel channel stiffeners over arches, anchored by 1¼-inch steel tie-rods; on pile foundation.

About 70 per cent. of the work on these culverts is completed to date.

The embankments on Section 48 will cut off travel to farm areas formerly reached by Rock Island Road, now built at about marsh level. This road will be diverted over the top of the embankment by sloped approaches. One of the approaches will pass over a diverted tidal creek by means of a pile bridge, already completed.

The sand and gravel filling for the embankments is being obtained from an area of 14 acres of upland, southeast of the intersection of

Palmer and Sea streets, purchased for this purpose by the Commonwealth. The marsh land upon which the embankments are filled is underlaid by strata of mud and peat to a maximum depth of 28 feet. The present contract, involving 180,000 cubic yards of filling, provides for the construction of embankments to sub-grade, about 12 feet above the level of the marsh and 7 feet below the proposed finished grade. This upper 7 feet of embankment fill will be formed of material displaced by the masonry structure of the sewer to be constructed within the embankment at a later date, after the filling has ceased settling into the marsh, and the embankment has reached a condition of equilibrium.

Embankment filling was begun June 20, 1901; 60,000 cubic yards of filling, equal to one-third of the contract volume, have been deposited to date. The average rate of filling has been 400 cubic yards, and the maximum 800 cubic yards, per day. Observations of the settlement of embankments already filled to sub-grade indicate a maximum vertical settlement slightly exceeding 4 feet. This implies that the settling of the embankment into the marsh has displaced about 30 per cent. of the cross-sectional area of mud underlying the actual location.

Section 49, Quincy.

Division Engineer in Charge. — Francis L. Sellew.
Contractor. — Charles G. Belden & Co., Syracuse, N. Y.

The complete section will extend from a point in the upland, adjacent to Quincy marsh, southeast of Palmer Street, westerly across Palmer Street and through the marsh, in a course generally parallel to Sea Street, to a point on the upland about 35 feet southeasterly from Sea Street, near the Adams homestead, a distance of 3,494 feet. For about one-third of this length the sewer will be constructed, at a later period, in filled embankments, as described under the preceding contract. The work of forming the embankments on 1,200 feet of this length forms part of that contract. The present contract for sewer construction applies to three lengths of 11 feet 3 inches by 12 feet 6 inches sewer, aggregating about 2,000 feet, in dry sand and gravel, at an average depth of 15 feet below the original surface, together with about 1,000 feet of embankment, formed of surplus material from the trenches, and three culverts crossing the location of the embankments. Details of these culverts are given in the following table: —

Culverts, Section 49.

LOCATION.	Cross-section.	Length (Feet).	Length over All (Feet).	Details of Construction.
Near Albatross Road, Station 10+65.	4' 0" circular,	74	99	Concrete, with brick lining; 2 12-foot lengths of cast-iron pipe immediately under sewer structure.
Near Curlew Road, Station 21+95.	4' 0" circular,	75	99	Concrete, with brick lining.
Near Adams homestead, Station 32+65.	2' 6" circular,	91	118	

Excavation was begun June 5, 1901. At the present time, about 1,900 feet of sewer and the whole of the culverts are completed; the filling of the embankments is also completed, but work remains to be done on the slopes.

Section 50, Quincy.

Division Engineer in Charge. — Francis L. Sellew.
Contractor. — Charles G. Belden & Co., Syracuse, N. Y.

This 11 feet 3 inches by 12 feet 6 inches sewer extends from a point in the upland, about 35 feet southeasterly from Sea Street, near the Adams homestead, westerly through Sea Street and private lands to Greenleaf Street, — a total distance of 3,071 feet. The sewer is nearly all in open cut, with an average depth of 18 feet, in dry sand and gravel. A short length will be constructed in embankment, where it crosses the end of a pond in the Adams home estate, near Mount Wollaston cemetery. A special foundation of boulder concrete is to be used through the pond. Where the sewer enters Sea Street, a modified cross-section is adopted for a length of 220 feet, owing to the low elevation of Sea Street in that vicinity.

Work was commenced on October 28, 1901. About 500 feet of sewer have been completed to date.

Section 51, Quincy.

Division Engineer in Charge. — Frederick D. Smith.
Assistant Engineer. — Seth Peterson.
Contractor. — Thomas F. Moore, Syracuse, N. Y.

The sewer extends northwesterly in Greenleaf Street, from near the Mount Wollaston Cemetery, to Hancock Street, a distance of 2,366 feet. It is 11 feet 3 inches by 12 feet 6 inches in diameter.

The work is in open cut, chiefly in coarse sand and gravel, free from water, at an average depth of 23 feet. The excavation is carried on by an excavating machine, invented and owned by the contractor.

Work was commenced at the lower end of the section in March, 1901. About 2,000 feet of sewer have been completed to date. Passing the end of Woodward Avenue, the invert of the sewer is reinforced by additional concrete, and further stiffened, by steel beams, over the location of a main sewer of the city of Quincy executed in tunnel at a lower elevation than the new sewer. The arch was reinforced with concrete for 250 feet east of Woodward Avenue and for 115 feet east of Valley Street. Two 30-inch branches have been inserted in the westerly side of the sewer, at Park Road and Putnam Street respectively, for the future connection of force mains from the sewage pumping station in Merrymount Park, Quincy. Additional 8-inch branches have been inserted at Park Road, Cedar Place, Putnam Street and Woodward Avenue.

Section 52, Quincy.

Division Engineer in Charge. — Frederick D. Smith.
Assistant Engineer. — Seth Peterson.
Contractor. — National Contracting Company, New York, N. Y.

The sewer begins at the westerly end of Greenleaf Street, at Hancock Street, crosses Hancock and Adams streets, private lands, and the New York, New Haven & Hartford Railroad (Plymouth Division) to Upland Road, and passes thence along Upland Road and Adams Street to beyond Oakland Avenue, a total distance of 2,774 feet. Of this length, about 250 feet, crossing Adams Street and private lands to the railroad, are expected to be in tunnel. The remaining 2,524 feet will be in open cut, in coarse sand and gravel with a large amount of rock, with an average depth of 17 feet above the rock excavation. A very small flow of water has been met with to date. The sewer is 11 feet by 12 feet 3 inches in diameter. Excavation began early in October, 1901, and has been carried on by cable excavating machinery. It has been largely confined, to date, to Adams Street, with the intention of leaving that street clear during the summer months. About 280 feet of trench have been excavated to date. A 10-inch branch has been built into the sewer at Goffe Street.

Section 53, Quincy.

Division Engineer in Charge. — **Frederick D. Smith.**
Assistant Engineer. — **Seth Peterson.**
Contractor. — **National Contracting Company, New York, N. Y.**

The sewer commences in Adams Street, southwest of Oakland Avenue. On leaving Adams Street, it passes westerly through private land and the location of the Furnace Brook Metropolitan Parkway for a distance of 1,900 feet. It is 11 feet by 12 feet 3 inches in diameter. The work will be wholly in open cut, having an average depth of 13 feet of earth excavation in sand and gravel, with a large amount of rock excavation in addition. The excavation is being carried on by cable excavator. Through the parkway location an embankment will be formed over the sewer to grades defined by the Metropolitan Park Commission, and special precautions will be taken to avoid, as far as possible, interference with the natural scenery of the vicinity. For a length of 700 feet, where the sewer passes through private land west of Adams Street, a temporary fence has been erected on the taking lines, on each side of the sewer, and the contractor confines his operations within the enclosure thus formed. Work commenced at the lower end early in October, 1901. About 200 feet of trench have been excavated to date.

Section 54, Quincy.

Division Engineer in Charge. — **Frederick D. Smith.**
Assistant Engineer. — **Seth Peterson.**
Contractor. — **National Contracting Company, New York, N. Y.**

The sewer begins in the location of the Furnace Brook Metropolitan Parkway, at a point about 1,600 feet northeasterly from its junction with Adams Street. It follows the parkway location and Adams Street in a westerly direction to a point in Adams Street, near Eaton's Ice Pond, and has a total length of 1,990 feet. It is 11 feet by 12 feet 3 inches in diameter, constructed in open cut with an average total depth of 18 feet. The excavation is through alluvial soil and sand, overlying large quantities of decayed slate ledge. A small amount of water is found in the excavation. Special precautions are taken to preserve the natural features along the sewer location, and the surplus earth is used in sub-grading a park boulevard, under the direction of the Metropolitan Park Commission's Engineer. Work was commenced November 1, 1901, and 100 feet have been excavated to date.

Section 55, Quincy and Milton.

Division Engineer in Charge. — **Frederick D. Smith.**
Assistant Engineer. — **Seth Peterson.**
Contractor. — **H. P. Nawn, Boston, Mass.**

This sewer, 11 feet by 12 feet in diameter, commences in Adams Street, near Eaton's Ice Pond, in Quincy, and extends in a westerly direction along Adams Street and across the Milton boundary line near Washington Street, to a point near Church Street, in Milton, a total distance of 3,555 feet.

The contract was let as a tunnel section with an average depth of 45 feet below the level of the street. For convenience of working, the contractor has sunk three shafts, one about 800 feet from the lower end, one near Beale Street, and one about 900 feet from the upper end of the section. Work on the upper shaft was commenced as early as December 1, 1900, and on the lower shaft two days later. The middle shaft was commenced April 8, 1901.

An easterly heading from the lower shaft has been driven 472 feet and a westerly heading 478 feet, making 950 feet in all. Of this length, 317 feet were wholly in rock, 155 feet in rock bottom with earth roof, 303 feet in hard-pan, and 105 feet in hard-pan with rock bottom.

From the middle shaft an easterly heading has been driven 366 feet. This was all in hard-pan except for a 60-foot length with sand roof. No westerly heading was driven, the contractor finding it more convenient to open-cut a length of 241 feet in sand, gravel and hard-pan, 45 feet deep, immediately adjoining the shaft. A heading has been begun at the westerly end of this cut, of which 20 feet have been driven to date.

The excavation of the upper shaft, in sand and gravel, with fine sand in the lower 12 feet, proceeded from December 1, 1900, to January 17, 1901, when it was suspended until March 9. It was then continued until the shaft reached grade, late in May. Pumping was then maintained until November 16, when an open cut was started at each end of the shaft. This now extends over a total length, including the shaft, of 132 feet, and is within 3 feet of grade. The flow of ground water through it has been as much as 1,240,000 gallons per day. In the month just closed it varied between 406,000 gallons and 974,000 gallons per day. The effect of the pumping has been observed over an area having a radius of 2,000

feet from the shaft, as indicated by the drying of 51 wells. A temporary town-water service has in each such case been put into the houses. These figures show that a total length of 1,719 feet has been excavated in tunnel and open cut, to date. The masonry sewer structure has been completed in 1,110 feet of this length, in which the sewer arch has been reinforced with concrete for a distance of 762 feet.

The 24-inch Metropolitan water main in Adams Street was moved for a total length of 725 feet, where the contractor found it convenient to open-cut instead of to tunnel.

Section 56, Milton.

Division Engineer in Charge. — Frederick D. Smith.
Assistant Engineer. — Seth Peterson.
Contractor. — National Contracting Company, New York, N. Y.

Commencing near Church Street, this sewer extends northwesterly through Adams Street to a point 800 feet beyond East Milton station, a total distance of about 1,495 feet. It is 10 feet 7 inches by 11 feet 7 inches in diameter, wholly in open cut, at an average depth of 31 feet. For about 350 feet at the westerly end of the section the excavation is in hard-pan, overlying slate ledge; the remainder is in earth, gravel and sand. The rock averaged 13 feet in depth, measured from its surface to the bottom of the trench. A very small amount of water was found throughout the section. Excavation was begun December 3, 1900, and 1,400 feet have been completed to date. Passing the East Milton branch of the New York, New Haven & Hartford Railroad, and for a length of about 300 feet at the lower end of the section, the sewer was reinforced by concrete spandrels carried to a height of 6 inches above the arch, and near the lower end about 125 feet of 24-inch Metropolitan water main were moved in a southerly direction, in order to clear the sewer trench.

An 8-inch branch has been inserted at Granite Avenue and a 15-inch branch near the upper end of the section.

Section 57, Milton.

Division Engineer in Charge. — Frederick D. Smith.
Assistant Engineer. — Seth Peterson.
Contractor. — J. W. Bustin & Co., Syracuse, N. Y.

This sewer, 10 feet 7 inches by 11 feet 7 inches in diameter, follows the centre line of that part of the proposed Milton boulevard extending from Adams Street to Pleasant Street, a distance of 1,874 feet. The work will be in open cut, through sand and gravel, with some clay, at an average depth of 22 feet. Some portions of the line will be covered by a low embankment, formed of surplus material from the trench, carried up to the sub-grade of the boulevard. Excavation was begun October 31, 1901, and about 300 feet have been completed to date. An 8-inch branch has been inserted about 165 feet east of Pleasant Street.

Section 58, Milton.

Division Engineer in Charge. — Frederick D. Smith.
Assistant Engineer. — Seth Peterson.
Contractor. — Latta & Terry Company, Philadelphia, Pa.

This sewer, 10 feet 7 inches by 11 feet 7 inches in diameter, follows the centre line of the proposed Milton boulevard for a length of 2,560 feet, commencing at Pleasant Street and ending in Centre Street. It will be in open cut throughout. Surplus earth from the trench will be used to form an embankment over the greater part of the length, finished at boulevard sub-grade. The average depth of excavation is 17 feet. Excavation will be largely in coarse sand and gravel, with superficial peat for a length of 800 feet near the upper end of the section. The cross-section will be modified in a special structure at Station 14+40, to allow of the passage over it of a double culvert taking the place of an open water course now crossing the boulevard location. Trench has been partially excavated for a length of 600 feet west of Pleasant Street.

Section 59, Milton.

Division Engineer in Charge. — Frederick D. Smith.
Assistant Engineer. — Seth Peterson.
Contractor. — H. P. Nawn, Boston, Mass.

Occupying the centre of the Milton boulevard location, this 10 feet 7 inches by 11 feet 7 inches sewer extends from Centre Street to Randolph Avenue, a distance of 2,567 feet. It will be in open cut, averaging 20 feet in depth below the original surface, with a low embankment, formed of surplus earth from the excavation, over its entire length, finished at boulevard sub-grade. The excavation will be in sand, gravel and clay. About 200 feet of trench have been excavated to grade. An 8-inch branch has been inserted at Centre Street, to provide for unsewered areas in Milton.

Section [illegible], Milton.

Division Engineer in Charge.—Frederick D. Smith.
Assistant Engineer.—Seth Peterson.
Contractor.—[illegible] Brown & Co., [illegible] N. Y.

This [illegible] feet 7 inches by [illegible] feet 7 inches sewer extends [illegible] along the center line of the [illegible] location from [illegible] Avenue to near Canton Avenue, a distance of [illegible] feet. It will be in open cut, averaging [illegible] feet deep. An embankment will [illegible] height of [illegible] feet above the original surface, will be formed of [illegible] excavated material over the greater part of its length and [illegible]. The excavation will be in sand, gravel and clay, [illegible] a depth of [illegible] feet. The contract was awarded October [illegible], and [illegible] progress has been made with excavation.

Section 62, Milton.

Division Engineer in Charge.—Frederick D. Smith.
Assistant Engineer.—Seth Peterson.
Contractors.—[illegible] W. & J. J. [illegible], Providence, R. I.

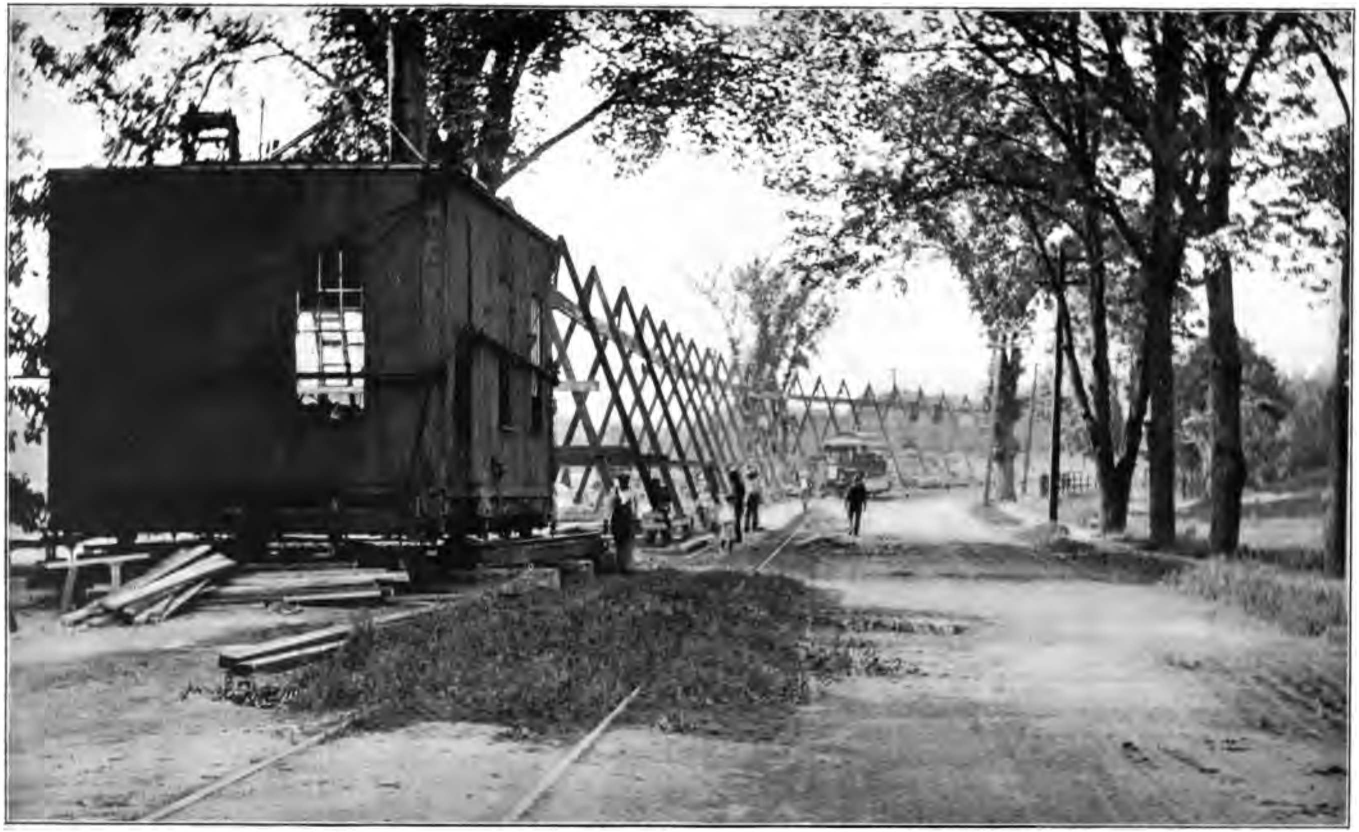
This 10 feet 7 inches by 11 feet 7 inches sewer is located in Brook Road, extending northwesterly from near Pine Tree Brook to a point 530 feet beyond Ridge Road, a distance of 2,174 feet. Of this length, 396 feet, near Ridge Road, are in rock tunnel. The remaining 1,778 feet are in open cut, averaging 27 feet in depth. The excavation in open cut is through sand and gravel, with rock in the bottom for two-thirds of its length at the upper end of the section.

An average of about 400,000 gallons of ground water per day has been pumped from the excavation. Work was begun December 10, 1900. The whole of the excavation in trench and tunnel is completed. About 200 feet of masonry remain to be constructed. Four 8-inch branches have been inserted at intervals of about 200 feet, to provide for unsewered areas in Milton.

Section 63, Milton.

Division Engineer in Charge.—Frederick D. Smith.
Assistant Engineer.—Seth Peterson.
Contractor.—National Contracting Company, New York, N. Y.

This is a 10 feet 7 inches by 11 feet 7 inches sewer, 2,262 feet in length, commencing in Brook Road, at a point 800 feet easterly from the Blue Hills Parkway. It follows Brook Road, crosses the



HIGH LEVEL SEWER—CONSTRUCTION WITH EXCAVATING MACHINE, IN BROOK ROAD, MILTON.

Metropolitan Blue Hills Parkway, and terminates in park lands southeast of the Neponset River. It is wholly in open cut, at an average depth of 25 feet. The excavation is in coarse sand and gravel, with rock in the first 700 feet length. Work was begun December 3, 1900, and 1,882 feet have been excavated to date. West of the Blue Hills Parkway, where the work is being carried on at two openings, the excavation is in wet sand and gravel, and large quantities of ground water are found, approximating 1,000,000 gallons per day at each opening. The arch was reinforced with concrete spandrels for a length of 150 feet near the river, up to the harder ground found near Brush Hill Road, and across the Metropolitan Blue Hills Parkway. An 18-inch branch has been inserted at Brush Hill Road and two 8-inch branches at intervals of about 300 feet.

Section 65, Hyde Park.

Division Engineer in Charge. — **C. Barton Pratt.**
Contractor. — **Beckwith & Quackenbush, Mohawk, N. Y.**

This sewer extends from the Neponset River, through Monponset and Baldwin streets, near the location of the New York, New Haven & Hartford Railroad (Midland Division). Of the total length of 900 feet, 640 feet, between River Street and the Neponset River, are 10 feet 7 inches by 11 feet 7 inches in diameter; the remaining 260 feet, northwest of River Street, are 9 feet 3 inches by 10 feet 2 inches in diameter. The existing Neponset valley sewer, in River Street, is temporarily passed through the completed sewer by a 24-inch cast-iron pipe. Two branches, 4 feet 6 inches in diameter, have been provided in the larger sewer at this point, one for the future connection of the Neponset valley sewer, and the other, on the opposite side, for a main sewer to provide for undrained areas of the city of Boston.

Between River Street and the river the excavation was largely in sand and gravel, with boulders. A small amount of water was found in the excavation. Between River Street and the railroad location the excavation was chiefly in felsite rock. Excavation was commenced on March 3, 1900.

Prior to September 29, 1900, 572 feet of the sewer had been completed. The section was completed on April 12, 1901, giving an average rate of progress, for the entire work, of 16 feet per week, with a maximum of 32 feet per week.

Section 66, Hyde Park.

Division Engineer in Charge. — **C. Barton Pratt.**
Contractor. — **Ed. W. & J. J. Everson, Providence, R. I.**

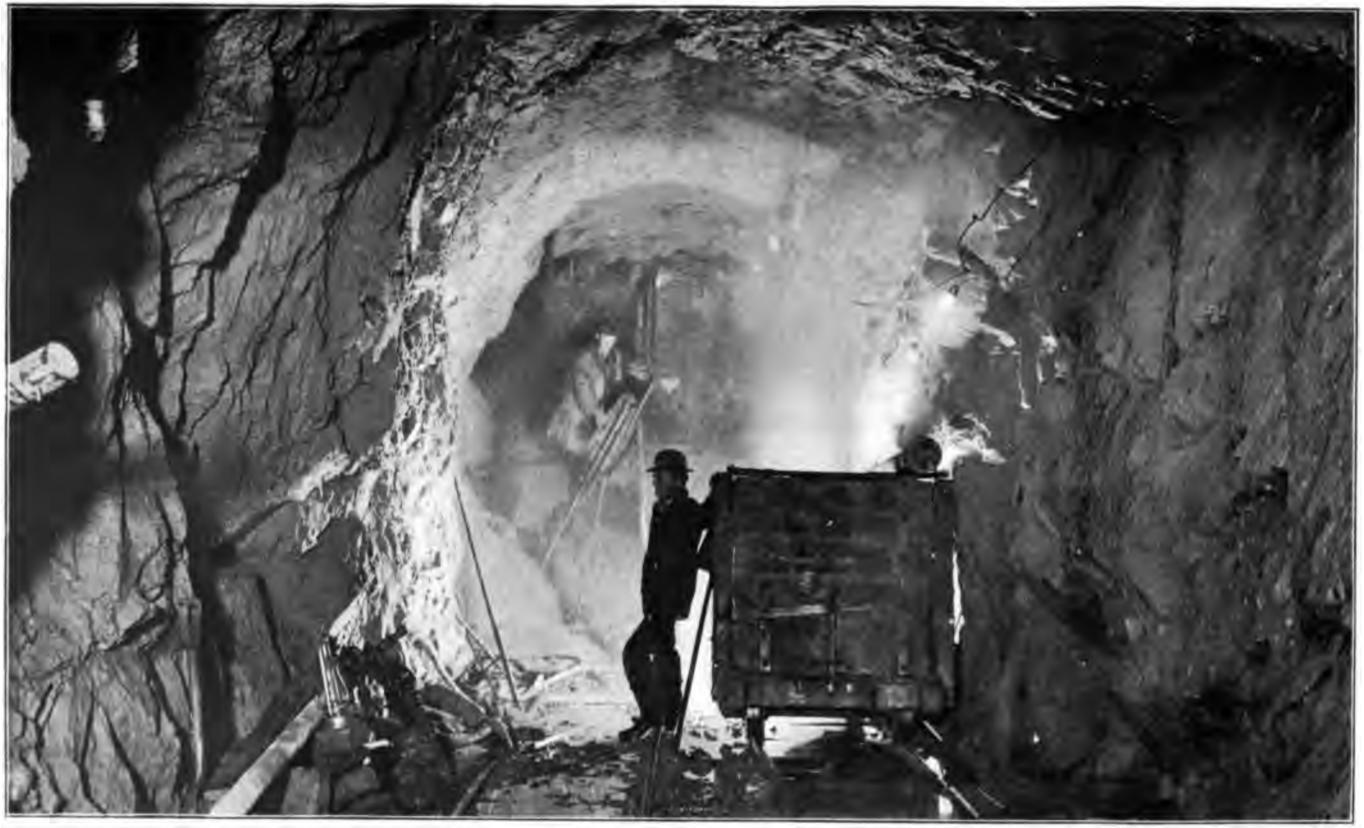
This sewer, 9 feet 3 inches by 10 feet 2 inches in diameter, 5,300 feet in length, was expected to be wholly in tunnel. At the date of the last report (September 29, 1900) 1,188 feet of tunnel excavation had been completed. For a length of 285 feet near Ralston Road, having an approximate depth of 24 feet, the contractor found it more convenient to excavate in open trench than to drive the tunnel as contemplated in the contract. The excavation of the open portion was carried on in August and September, 1901. Except for a length of about 20 feet, it was in rock and boulders, rising to an average of 15 feet above the sewer invert, overlaid by a mixture of hard-pan, sand and gravel. Including this 285 feet length, a total of 5,050 feet has been excavated to date. This indicates that during the fifteen months now under review an average rate of excavation of 60 feet per week has been maintained, rising to a maximum of 90 feet. The excavation in the tunnel headings has been in felsite of a very hard and flinty variety, with occasional trap dikes. No masonry has been introduced into headings to date. Approximately 130 feet of masonry have been built in the open cut. The tunnel excavation has been carried on during the year from the central shaft in Ruskin Road, near the middle of the section, fully described in the last report, and has advanced about equally northeast and southwest thereof.

The single fatality on the high-level sewer construction to date occurred on this section in February, 1901. A laborer, attempting to alight from a moving lift in the Ruskin Road shaft, fell to the bottom of the shaft and was killed.

Section 67, Hyde Park.

Division Engineer in Charge. — **Frank I. Capen.**

This section has a total length of 327 feet, extending from the upper end of Section 66 tunnel, across Stony Brook, to near the Hyde Park and West Roxbury boundary line. It includes about 215 feet of ordinary 9 feet 3 inches by 10 feet 2 inches sewer structure, at an average depth of 17 feet, and two lines, each 84 feet in length, of 60-inch cast-iron pipe under Stony Brook, with pipe



HIGH LEVEL SEWER — CONSTRUCTION OF TUNNEL IN ROCK IN RUSKIN ROAD, HYDE PARK.

chambers at either end for controlling and diverting the flow of sewage through the individual lines of pipe.

The work is being carried on by day-labor, under the direct supervision of the Engineer. It was begun October 24, 1901. At the present time about 40 feet of pipe have been laid in each line of crossing, and the pipe chambers are well advanced.

Section 68, Hyde Park and West Roxbury.

Division Engineer in Charge. — C. Barton Pratt.
Contractor. — Beckwith & Quackenbush, Mohawk, N. Y.

Commencing in Hyde Park, near the West Roxbury boundary line, this sewer extends through private lands in West Roxbury, adjacent to Stony Brook, to the junction of Ashland and Canterbury streets; thence along Ashland Street, Hammatt Road and Hadwin Way to Hyde Park Avenue, in West Roxbury, a total distance of 2,738 feet. The length of 1,735 feet below Canterbury Street is 9 feet 3 inches by 10 feet 2 inches in diameter. The remaining 983 feet are 8 feet 9 inches by 9 feet 8 inches. The entire section was completed prior to September 29, 1900, with the exception of 45 feet of the larger sewer near the intersection of Ashland and Canterbury streets. The character of the work was described on page 63 of the previous report.

Excavation was begun November 20, 1899, and the work was completed December 1, 1900, showing an average rate of progress of 51 feet per week. A maximum of 120 feet per week was accomplished.

Two branches were inserted in the larger sewer at Canterbury Street. On the westerly side a 24-inch brick connection, and on the easterly side a 12-inch pipe, were provided for unsewered Boston areas.

Section 69, West Roxbury.

Division Engineer in Charge. — C. Barton Pratt.
Contractor. — Beckwith & Quackenbush, Mohawk, N. Y.

This sewer, 8 feet 9 inches by 9 feet 8 inches in diameter and 2,596 feet in length, is in Hyde Park Avenue, between Hadwin Way and Larch Place. It was commenced November 29, 1899, and on September 29, 1900, a length of 1,990 feet had been completed, as detailed on page 63 of the previous report.

The work was in open trench, with an average depth of 26 feet.

For a length of 900 feet from the commencement of the work, in Hadwin Way, the excavation was in gravel and clay, with hard-pan and some ledge in the bottom. Between stations 9 + 00 and 17 + 00 it was in sand, very fine towards the bottom, and involving, for a length of 300 feet near Mount Hope station, the use of tubular wells to secure a foundation. From Station 17 + 00 to the upper end of the section the excavation was similar to the first 900 feet.

The upper length of 609 feet, constructed during the period now under review, was in sand, clay and hard-pan, in open trench with an average depth of about 30 feet. For 100 feet near Larch Place, at the upper end of the section, rock was found in the bottom of the trench, rising to an average height of 6 feet above sewer grade. The section was completed July 6, 1901. This indicates a rate of progress, for the entire work, of 30 feet per week, with a maximum of 95 feet.

A 12-inch pipe was inserted in the sewer, near Mount Hope Street, to provide for unsewered areas of the city of Boston.

Section 70, West Roxbury.

Division Engineer in Charge. — C. Barton Pratt.
Contractor. — Charles Linehan, Cambridge, Mass.

This sewer extends from Hyde Park Avenue, through Larch Place, under the main line of the New York, New Haven & Hartford Railroad, through the extension of Harrison Street, along private lands adjoining the railroad and Stony Brook, under Washington Street and in private lands to South Street, at Bussey arch, and along South Street to Bussey Street. The total length of the section is 3,740 feet, but the actual length of sewer included in the contract is 230 feet less, owing to the omission of two lengths in the line, referred to on page 64 of the previous report. The sewer is 8 feet 9 inches by 9 feet 8 inches in diameter, and is built partly in open cut and partly in embankment. At the date of the previous report 1,230 feet of sewer were completed. At the present time 3,260 feet have been completed, leaving only 200 feet in Larch Place and 50 feet in embankment on the meadows near Stony Brook to be constructed. This indicates an average rate of progress, during the fifteen months under review, of 31 feet per week. A maximum of 45 feet per week has been reached. Under the railroad location the sewer arch has been reinforced with concrete spandrels, carried up to 6 inches above the arch. A branch, about 3 feet in diameter, has been provided in Harrison Street for the connection of a main sewer from unsewered areas of the city of Boston.

Section 71, West Roxbury.

Division Engineer in Charge. — C. Barton Pratt.
Contractor. — Charles F. Taylor & Co., Syracuse, N. Y.

Of the total length of 2,193 feet of 8 feet 9 inches by 9 feet 8 inches sewer comprising this section, 188 feet are in tunnel, the remaining 2,005 feet in open trench. The open trench extends along South Street, from Bussey Street to the entrance to Bussey Woods, and thence through private lands for a further distance of 1,000 feet. The line then re-enters South Street in the short tunnel which completes the section.

For a length of 443 feet in private lands the sewer is in shallow open cut, finished by an embankment about 3 feet above the outside of the sewer arch, extended to join the slope of the hill on the west.

The average depth of excavation in the open trench in South Street was about 18 feet; in the open cut and embankment it was about 8 feet. The tunnel was in sand and gravel. The open cut was principally in sand and gravel, with some clay. Rock was found about 200 feet from the beginning of the section, and beds of peat extended below the elevation of the sewer foundation for a length of 175 feet near Station 15+00. The peat was removed and replaced by concrete filling. A maximum volume of 500,000 gallons of ground water per day was handled by the pumps.

At the close of the last report about 1,100 feet, including the tunnel, had been completed. The remainder of the section was completed on July 19, 1901. The average rate of progress per week, over the entire section, was 8 feet in tunnel and 33 feet in the remainder of the work. A maximum of 120 feet per week was attained in open cut and embankment.

Section 72, West Roxbury.

Division Engineer in Charge. — C. Barton Pratt.
Contractor. — Jones & Meehan, Boston, Mass.

This 8 feet 9 inches by 9 feet 8 inches sewer is 3,010 feet in length. It extends from near the Bussey Institution, along South Street, across the Arborway and still along South Street to the easterly side of St. Joseph Street. From the beginning of the section to the northeasterly margin of the Arborway, a length of 1,140 feet, the sewer is in tunnel, at an average depth of about 38 feet. The remainder is in trench, averaging 20 feet in depth.

Work was commenced on two tunnel shafts and the open cut October 8, 1900. The excavation in both tunnel and open cut was mainly in sand and gravel, with a small amount of water. Near St. Joseph Street, for a length of 300 feet, the lower portion of the trench was in fine sand, moving under a head of water. Three driven wells assisted in completing the trench excavation and securing a stable foundation for the sewer structure. The entire sewer in this length was built in Portland concrete and Portland brickwork. Portland concrete spandrels were also carried up to the height of the top of the arch. The character of the excavation in this 300 feet length considerably delayed the completion of the section. Crossing under the Goldsmith Brook conduit, at St. Joseph Street, the arch was depressed 2½ feet, and the section reinforced with tie-rods and rolled beams.

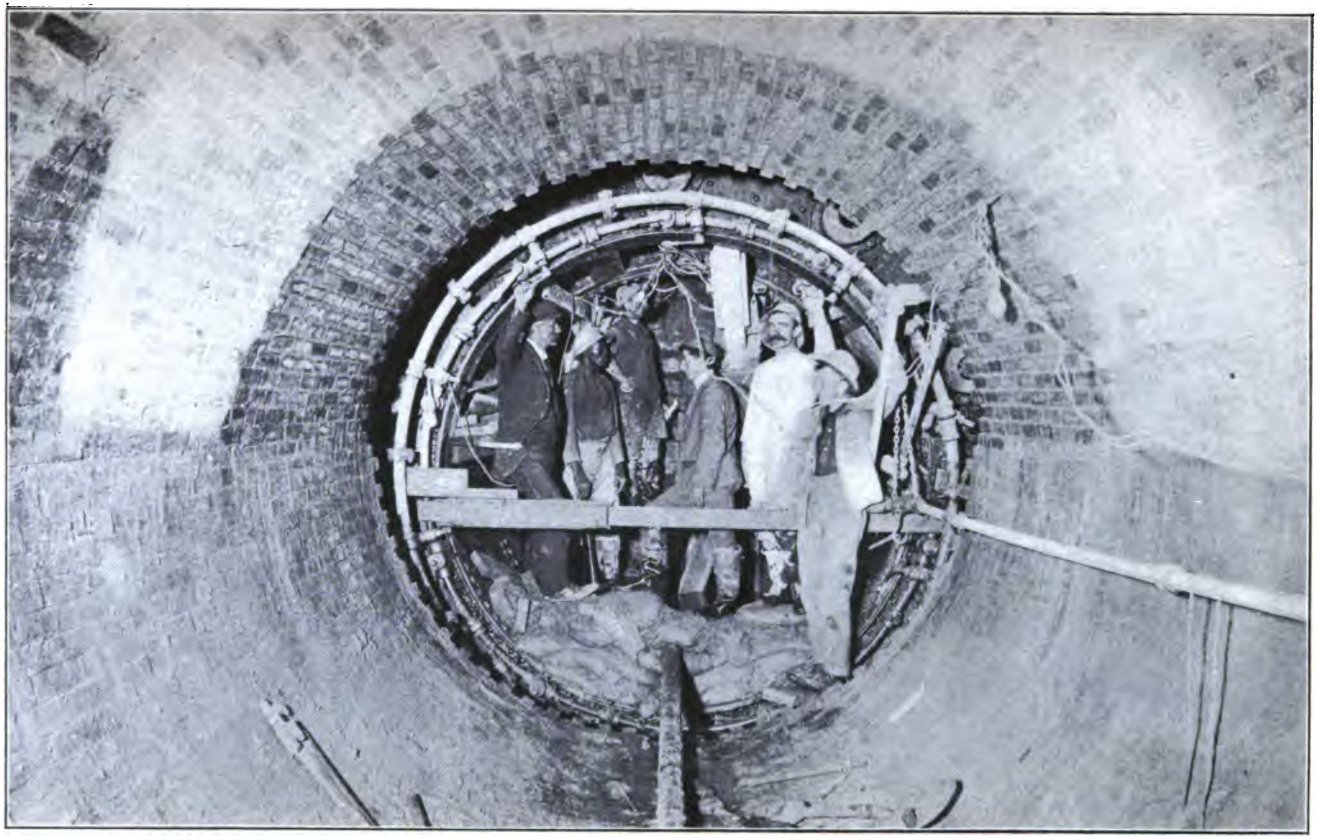
The open cut was completed October 1, 1901, indicating an average rate of trench excavation of 39 feet per week, with a maximum of 150 feet. The whole of the tunnel, with the exception of 40 feet, has been excavated during the period under review. The average rate of excavation in tunnel was 17 feet per week, with a maximum of 46 feet.

Section 73, West Roxbury.

Division Engineer in Charge. — C. Barton Pratt.
Contractor. — National Contracting Company, New York, N. Y.

This 9-foot circular sewer, in South and Centre streets, extends from near St. Joseph Street to near Boylston Street, a distance of 4,775 feet. The entire length is designed to be in tunnel, at an average depth of about 50 feet. In view of the probable use of compressed air with shields in the whole or portions of the work, a circular cross-section is adopted in place of the usual horse-shoe type of sewer.

Of the total length of 4,775 feet, about 1,400 feet of the tunnel headings will be in Roxbury pudding-stone, and the remainder in sand. Two shafts have been sunk to grade, one near Lakeville Place, in rock; the other at Pond Street, in sand. The excavation



HIGH LEVEL SEWER—CONSTRUCTION OF CIRCULAR TUNNEL WITH AIR COMPRESSOR AND METALLIC SHIELD, IN CENTRE STREET, JAMAICA PLAIN.

at the former was begun December 1, 1900, and completed February 7, 1901. The latter was begun February 1 and completed May 1, 1901. To date, 1,350 feet of rock heading have been excavated, located about equally north and south of the shaft in Lakeville Place. About 100 feet of concrete invert have been built in this length.

At the Pond Street shaft a metallic shield and air compressors were installed July 1, 1901, and a start was made to drive a southerly heading from this shaft by the pneumatic process. To date, no substantial progress has been made with this portion of the section.

Section 74, West Roxbury and Roxbury.

Division Engineer in Charge. — C. Barton Pratt.
Contractor. — H. P. Nawn, Boston, Mass.

Commencing in Centre Street, near Boylston Street, in West Roxbury, this sewer extends through Centre and Day streets to near Heath Street, in Roxbury, a distance of 2,985 feet, at an average depth of 54 feet, increasing to 65 feet. It is wholly in rock tunnel, with the exception of 190 feet of open cut, in sand and gravel, between Hutchins Avenue and Minden Street. Of the total length, the lower portion, below Perkins Street, nearly 1,000 feet in length, is 8 feet 3 inches by 9 feet 2 inches in diameter. A reduction in size to 6 feet 6 inches by 7 feet takes place in a bell-mouth junction at this point, from which the main line of the high-level sewer will ultimately be extended to Newton and other areas, for the relief of the existing low level sewers in the Charles River valley. The smaller sewer included in this section forms the lower end of the branch sewer intended mainly for the reception of sewage to be lifted at the proposed pumping station in Ward Street.

Work was begun September 26, 1900. The tunnel excavation is completed. The sewer has been constructed in the open cut and in about 1,800 feet of the tunnel portion, leaving about 1,000 feet of heading in which the masonry has yet to be completed.

The rate of excavation through the rock tunnel for the smaller sewer has averaged 31 feet per week, with a maximum of 60 feet. In the tunnel for the larger sewer it averaged 24 feet, rising to a maximum of 40 feet per week.

Near Grotto Glen an 18-inch brick connection has been left in the easterly side of the sewer.

Section 75, Roxbury.

Division Engineer in Charge. — C. Barton Pratt.
Original Contractor. — Shailer-Schniglau Company, Chicago, Ill.
Contractor for Parts of Section. — Ed. W. & J. J. Everson, Providence, R. I.

This is a tunnel section, largely in rock, consisting of 3,070 feet of 6 feet 6 inches by 7 feet sewer, passing under Parker Hill, at a maximum depth of 175 feet. Commencing at the junction of Day and Heath streets, the sewer passes under private lands and across intersecting streets for a distance of 1,700 feet. It then enters Calumet Street and continues along St. Alphonsus Street to a point about midway between Tremont and Smith streets. It will end at this point in a special bell-mouth structure, designed to receive the delivery ends of the two 48-inch force mains from the Ward Street pumping station.

Work was commenced on the Day Street shaft May 17, 1900. The last report, pages 67 and 68, contains a detailed description of the peculiar geological formation through which the first 288 feet of heading were driven.

Between September 29, 1900, and August 26, 1901, a further length of 612 feet was driven and lined with masonry. The excavation has been largely in boulder clay or hard-pan. At the northerly end of the heading, for a length of 50 feet, the conglomerate or pudding-stone gradually rises from the bed of the tunnel until it occupies the whole heading. The structure in the greater part of this length is reinforced with Portland concrete, and the arch is built in Portland brickwork. On December 22, 1900, the contractor began to sink a second shaft, 65 feet deep, on St. Alphonsus Street, near Alleghany Street. This shaft is entirely in Roxbury pudding-stone, which rises to the surface at this point. It was completed, and work started on the headings in each direction, March 6, 1901, when work at this shaft was suspended. On August 26 the entire work was abandoned by the contractor. The remainder of the section was advertised, and a contract for it awarded to Ed. W. & J. J. Everson of Providence, R. I., who have carried on the work since October 11. From that date until December 18 the contractor was pumping out the shaft, erecting machinery and preparing for work in the headings. From December 18 to date about 50 feet of heading have been driven.

Section 76, Roxbury.

This section will consist of two lines of 48-inch cast-iron force main, connecting the proposed pumping station on Ward Street with the 6 feet 6 inches by 7 feet sewer on St. Alphonsus Street. The lines will aggregate 3,000 feet in length. There have been purchased from the water works division and delivered on the pumping station lot 480 feet of 48-inch pipe, together with a pipe derrick and appurtenances, at a cost of $3,567.84.

Section 77, Roxbury.

This section includes the pumping station and connections with the suction sewer and force mains. The pumping station lot, comprising an area of about 100,000 square feet, located at the southeasterly angle of Ward and Vancouver streets, was purchased January 19, 1900, for $61,300.20. Studies have been made of foundations for engines and pumps, and the connection of the plant with the suction sewer and force mains. A contract for two 50,000,000-gallon, vertical, triple-expansion, 60-inch stroke pumping engines, with boilers and other appurtenances, has been awarded to the Allis-Chalmers Company of Milwaukee, Wis., for the sum of $204,000. The engines are to be erected, ready for service, within two years. The temporary buildings on the pumping station lot have been removed, and the lot cleared in readiness for building operations.

CEMENT TESTING.

About 59,000 barrels of Portland and 24,000 barrels of Rosendale cement have been used during the fifteen months under review. The cement was subjected to the usual careful tests for fineness, tensile strength, specific gravity, checking, cracking, etc. The results under the first two heads are summarized in the following table: —

Summary of Cement Tests made by Metropolitan Sewerage Works, October 1, 1900, to December 31, 1901.

BRAND.	Number of Barrels used.	Composition of Briquettes.	Fineness.			Twenty-four Hours.		Seven Days.		Twenty-eight Days.		Three Months.		Six Months.		Nine Months.		One Year.		Eighteen Months.		Two Years.	
			Per Cent. Residue No. 50 Sieve.	Per Cent. Residue No. 100 Sieve.	Per Cent. Residue No. 120 Sieve.	Briquettes.	Pounds per Square Inch.	Briquettes.	Pounds per Square Inch.	Briquettes.	Pounds per Square Inch.	Briquettes.	Pounds per Square Inch.	Briquettes.	Pounds per Square Inch.	Briquettes.	Pounds per Square Inch.	Briquettes.	Pounds per Square Inch.	Briquettes.	Pounds per Square Inch.	Briquettes.	Pounds per Square Inch.
Portland.																							
Alpha,	2,831	Neat,	0	9.7	12.7	155	341	169	806	15	911	5	893	5	721	-	-	5	802	-	-	-	-
		2:1,	0	9.7	12.7	-	-	165	348	20	492	5	623	5	594	-	-	5	594	-	-	-	-
Atlas,	28,890	Neat,	0	9.8	12.2	715	386	827	690	170	796	5	881	5	879	5	777	10	822	-	-	-	-
		2:1,	0	9.8	12.1	-	-	785	364	180	435	40	569	10	566	10	653	35	499	-	-	5	682
Catskill,	287	Neat,	0	13.6	15.8	10	346	40	654	24	766	-	-	-	-	5	884	5	818	-	-	-	-
		2:1,	0	13.6	15.7	-	-	25	339	15	485	5	774	-	-	5	552	5	579	-	-	-	-
Lehigh,	13,320	Neat,	0	10.0	13.5	350	358	360	741	80	862	10	759	10	852	-	-	5	1,086	-	-	-	-
		2:1,	0	10.0	13.4	-	-	324	392	100	486	30	552	10	596	-	-	5	561	-	-	-	-
Star,	9,030	Neat,	0	9.4	11.9	280	346	225	754	50	850	5	814	-	-	5	1,038	14	814	5	702	-	-
		2:1,	0	9.6	12.0	-	-	224	372	70	443	15	377	-	-	5	549	10	585	5	546	5	582
Vulcanite,	4,840	Neat,	0	9.6	11.7	210	338	225	816	40	893	5	590	5	623	-	-	5	1,003	5	979	-	-
		2:1,	0	9.5	11.6	-	-	185	465	40	494	25	626	5	553	-	-	5	553	5	597	-	-
Totals,	59,198	Neat,	0	9.8	12.5	1,720	364	1,846	731	379	831	30	783	25	785	15	900	44	867	10	841	-	-
		2:1,	0	9.8	12.4	-	-	1,708	380	425	458	120	588	30	579	20	602	65	535	10	571	10	632
Rosendale.																							
Crescent,	55	Neat,	3.0	15.0	20.0	10	187	10	180	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		1½:1,	3.0	15.0	20.0	-	-	10	76	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hoffman,	7,183	Neat,	3.4	15.3	17.5	165	146	170	170	45	261	-	-	-	-	-	-	-	-	-	-	-	-
		1½:1,	3.3	15.8	17.5	-	-	135	68	45	169	10	295	-	-	-	-	-	-	-	-	-	-
Newark and Rosendale,	12,225	Neat,	3.8	15.7	18.2	370	143	441	156	90	215	10	301	-	-	5	412	15	339	-	-	5	351
		1½:1,	4.0	16.0	18.6	-	-	395	70	75	150	5	306	5	304	5	238	10	201	5	267	5	281
Norton,	1,198	Neat,	3.2	13.5	15.8	170	149	215	155	49	190	15	303	-	-	-	-	5	363	-	-	-	-
		1½:1,	3.1	13.4	15.7	-	-	215	68	45	161	5	247	-	-	-	-	5	247	-	-	-	-
Olympia,	3,162	Neat,	3.7	16.3	18.5	100	168	114	172	15	236	-	-	5	364	10	322	10	327	-	-	-	-
		1½:1,	3.7	16.3	18.6	-	-	123	66	20	156	5	240	5	257	-	-	10	194	-	-	5	233
Totals,	23,823	Neat,	3.6	15.2	17.6	815	149	950	161	199	220	25	302	5	364	15	352	30	339	-	-	5	351
		1½:1,	3.6	15.3	17.8	-	-	878	68	185	158	25	276	10	281	5	238	25	207	5	267	10	291

MAINTENANCE.

Scope of Work and Force Employed.

In addition to the construction already described, the maintenance of the Metropolitan sewerage systems involves the operation of 5 pumping stations, with about 82 miles of Metropolitan sewers receiving sewage discharged into them at 240 points by 830 miles of town and city sewers, and the care and study of siphons crossing under rivers and tidal creeks.

At the present time there is a total maintenance force of 83 men. This includes 45 engineers and other employés at the pumping stations, and 38 men who care for pumping station grounds and 82 miles of Metropolitan sewers with special structures. Five teams are also employed.

The three following tables show in detail the use made of the completed systems: —

NORTH METROPOLITAN SYSTEM.

Table showing Cities and Towns delivering Sewage to this System; Approximate Miles of Sewer connected; Estimated Populations and Areas now contributing; Total Areas ultimately to contribute, and Present Populations on Such Areas; Ratios of Present Contributing Areas to Ultimate Areas, and Ratios of Populations now contributing to Present Total Populations.

[Populations of May 1, 1901.]

CITIES AND TOWNS.	Miles of Local Sewer connected.	Separate or Combined.	Number of Connections with Local Sewers.	Estimated Number of Persons served by Each House-connection.*	Estimated Population now contributing Sewage.	Estimated Present Total Population.	Estimated Area now contributing Sewage.	Area ultimately to contribute Sewage.	Ratio of Contributing Population to Present Total Population.	Ratio of Contributing Area to Ultimate Area.
							Square Miles.	Square Miles.	Per Cent.	Per Cent.
Boston (Deer Island), .	0.30	Separate, .	-	-	1,300†	1,300	-	-	100.0	-
Winthrop, ...	25.43	Separate, .	1,501	4.3	6,454	6,900	1.19	1.61	93.5	73.9
Boston (East Boston), .	20.00	Separate and combined.	4,900	8.8	43,120	46,800	0.71	2.18	92.1	32.6
Chelsea, ...	7.96	Combined, .	1,280	6.7	8,576‡	35,300	0.38	2.24	24.3	17.0
Everett, ...	34.87	Separate, .	2,746	5.6	15,378	26,700	1.68	3.34	57.6	50.3
Malden, ...	44.55	Separate, .	3,587	5.2	18,652	35,800	2.49	5.07	52.1	49.1
Melrose, ...	30.51	Separate, .	1,986	4.1	8,143	13,600	1.48	3.73	60.0	39.7
Boston (Charlestown), .	20.40	Separate and combined.	5,000	7.9	39,500§	40,800	0.64	1.27	96.8	50.4
Cambridge, . . .	111.28	Separate and combined.	13,768	6.8	93,622	96,500	4.92	6.11	97.0	80.5
Somerville, . . .	79.65	Separate and combined.	11,605	5.3	61,507	65,600	3.27	3.96	93.8	82.6
Medford, ...	45.61	Separate, .	2,502	5.5	13,761	20,100	2.39	8.35	68.5	28.6
Winchester, . . .	18.62	Separate, .	599	5.2	3,115	7,800	0.95	5.95	40.0	16.0
Woburn, ...	12.22	Separate, .	774‖	5.4	4,180	14,700	0.89	12.71	28.5	7.0
Stoneham, . . .	10.38	Separate, .	361	4.3	1,552	6,300	0.56	5.50	24.6	10.2
Arlington, . . .	17.90	Separate, .	629	6.2	3,900	9,400	1.62	5.20	41.5	31.2
Belmont, ...	6.13	Separate, .	183	6.3	1,573¶	4,500	0.76	4.66	35.0	16.3
Wakefield,** . . .	-	-	-	-	-	9,900	-	7.65	-	-
Lexington,** . . .	-	-	-	-	-	2,800	-	5.11	-	-
Total, . . .	485.81	-	51,421	6.8	324,333	444,800	23.93	84.64	72.9	28.3

* Estimated from assessors' statement of the number of houses in each city or town, and the population from census of 1900 extended to 1901.

† Estimated by Superintendent J. R. Gerrish of the Institution on Deer Island.

‡ The Pearl Street district of Chelsea temporarily excluded, owing to connection not being properly maintained.

§ Including 30 persons at navy yard.

‖ Exclusive of Mystic valley sewer and tanneries.

¶ Including 2 connections with McLean Hospital, having an estimated population of 420.

** Wakefield and Lexington not connected.

SOUTH METROPOLITAN SYSTEM.

Table showing Cities and Towns delivering Sewage to this System; Approximate Miles of Sewer connected; Estimated Populations and Areas now contributing; Total Areas ultimately to contribute, and Present Populations on Such Areas; Ratios of Present Contributing Areas to Ultimate Areas, and Ratios of Populations now contributing to Present Total Populations.

[Populations of May 1, 1901.]

CITIES AND TOWNS.	Miles of Local Sewer connected.	Separate or Combined.	Number of Connections with Local Sewers.	Estimated Number of Persons served by Each House-connection.*	Estimated Population now contributing Sewage.	Estimated Present Total Population.	Estimated Area now contributing Sewage.	Area ultimately to contribute Sewage.	Ratio of Contributing Population to Present Total Population.	Ratio of Contributing Area to Ultimate Area.
							Square Miles.	Square Miles.	Per Cent.	Per Cent.
Boston (Back Bay), .	20.70	Separate and combined.	1,300	15.8	20,540	21,600	1.12	1.61	95.1	69.6
Boston (Brighton), .	50.20	Separate and combined.	2,330	5.6	13,048	20,800	3.09	4.27	62.7	72.4
Brookline, . . .	51.18	Separate and combined.	2,575	6.5	16,738	21,800	2.92	6.81	76.8	42.9
Newton, ...	91.57	Separate, .	4,265	5.6	23,884	36,300	6.12	18.03	65.8	33.9
Watertown, . . .	29.97	Separate, .	1,404	5.0	6,950	10,500	1.67	4.04	66.2	41.3
Waltham, . . .	38.12	Separate, .	2,520	5.2	13,104	24,900	2.40	13.63	52.6	17.6
Boston (Dorchester), .	12.47	Separate and combined.	944	6.8	6,419	36,600	0.80	4.89	17.5	16.4
Milton, ...	3.24	Separate and combined.	69	5.4	373	7,100	0.18	12.59	5.3	1.4
Hyde Park, . . .	15.82	Separate, .	516	7.9	4,079	13,900	0.84	4.57	29.3	18.4
Dedham, ...	1.27	-	7	7.1	50	7,100	0.06	9.40	0.7	0.6
Boston (Roxbury), .	-	-	-	-	-	28,200	-	1.23	-	-
Boston (West Roxbury),	3.70	Separate, .	130	7.2	936	25,900	0.21	8.92	3.6	2.3
Quincy, ...	26.00	-	665	6.0	4,000	25,800	1.34	12.56	15.5	10.7
Total, . . .	344.24	-	16,725	6.6	110,121	280,500	20.75	102.55	39.3	20.2

* Estimated from assessors' statement of the number of houses in each city or town, and the population from census of 1900 extended to 1901.

WHOLE METROPOLITAN SYSTEM.

Table showing Areas delivering Sewage to the Entire System, inclusive of added High-level Area; Approximate Miles of Sewer connected; Estimated Populations and Areas now contributing; Total Areas ultimately to contribute, and Present Populations on Such Areas; Ratios of Present Contributing Areas to Ultimate Areas, and Ratios of Populations now contributing to Present Total Populations.

[Populations of May 1, 1901.]

SYSTEM.	Miles of Local Sewer connected.	Separate or Combined.	Number of Connections with Local Sewers.	Estimated Number of Persons served by Each House-connection.	Estimated Population now contributing Sewage.	Estimated Present Total Population.	Estimated Area now contributing Sewage.	Area ultimately to contribute Sewage.	Ratio of Contributing Population to Present Total Population.	Ratio of Contributing Area to Ultimate Area.
							Square Miles.	Square Miles.	Per Cent.	Per Cent.
North Metropolitan, .	485.81	Separate and combined.	51,421	6.3	324,333	444,800	23.93	84.64	72.9	28.3
South Metropolitan, .	344.24	Separate and combined.	16,725	6.6	110,121	280,500	20.75	102.55	39.3	20.2
Total, . . .	830.05	-	68,146	6.4	434,454	725,300	44.68	187.19	59.9	23.9

CAPACITY AND RESULTS.

The following tables summarize the pumping station records for the fifteen months' period for the North Metropolitan stations and for nine months for the Quincy station: —

Deer Island Pumping Station.

At this station are three submerged centrifugal pumps, with impellers or wheels 8.25 feet in diameter, driven by triple-expansion engines of the Reynolds-Corliss type: —

Contract capacity of pumps: 45,000,000 gallons each, with 19-foot lift.
Average duty for the year: 54,500,000 foot-pounds.
Average quantity raised each day: 52,000,000 gallons.
Force employed: 3 engineers, 3 firemen, 6 screenmen and 1 reliefman.
Coal used: first-quality Cumberland, costing from $3.79 to $3.95 per ton.

Table of Approximate Quantities, Lifts and Duties at the Deer Island Pumping Station of the North Metropolitan System.

Months.	Total Pumpage (Gallons).	Average per Day (Gallons).	Minimum Day (Gallons).	Maximum Day (Gallons).	Average Lift (Feet).	Average Duty (ft.-lbs. per 100 lbs. Coal).
1900-1901.						
October,	1,394,400,000	45,000,000	35,700,000	70,200,000	11.48	52,700,000
November,	1,386,100,000	46,200,000	34,300,000	86,200,000	11.31	51,300,000
December,	1,626,100,000	52,500,000	38,300,000	85,300,000	11.44	54,100,000
January,	1,389,600,000	44,800,000	33,900,000	63,300,000	11.64	52,700,000
February,	1,197,900,000	42,800,000	38,300,000	47,800,000	11.35	49,800,000
March,	1,835,200,000	59,200,000	39,300,000	100,200,000	11.84	58,000,000
April,	2,507,500,000	83,600,000	62,500,000	125,300,000	12.49	65,100,000
May,	2,318,000,000	74,800,000	58,100,000	113,800,000	12.20	65,700,000
June,	1,510,400,000	50,300,000	43,800,000	68,400,000	11.18	52,200,000
July,	1,377,600,000	44,400,000	34,800,000	67,600,000	10.92	52,700,000
August,	1,326,400,000	42,800,000	36,000,000	68,700,000	11.11	48,800,000
September,	1,296,300,000	43,200,000	36,900,000	55,100,000	11.11	52,500,000
October,	1,349,000,000	43,500,000	35,300,000	66,400,000	10.97	52,700,000
November,	1,256,400,000	41,900,000	31,800,000	83,400,000	11.36	48,700,000
December,	2,011,400,000	64,900,000	38,300,000	120,300,000	11.70	61,000,000
Total,	23,782,300,000	-	-	-	-	-
Average,	-	52,000,000	39,800,000	81,500,000	11.47	54,500,000

East Boston Pumping Station.

At this station are three submerged centrifugal pumps, with impellers or wheels 8.25 feet in diameter, driven by triple-expansion engines of the Reynolds-Corliss type.

Contract capacity of pumps: 45,000,000 gallons each, with 19-foot lift.
Average duty for the year: 57,800,000 foot-pounds.
Average quantity raised each day, 49,200,000 gallons.
Force employed: 3 engineers, 3 firemen, 6 screenmen and 1 reliefman.
Coal used: first-quality Cumberland, costing from $3.95 to $3.98 per ton.

Table of Approximate Quantities, Lifts and Duties at the East Boston Pumping Station of the North Metropolitan System.

MONTHS.	Total Pumpage (Gallons).	Average per Day (Gallons).	Minimum Day (Gallons).	Maximum Day (Gallons).	Average Lift (Feet).	Average Duty (ft.-lbs. per 100 lbs. Coal).
1900-1901.						
October,	1,245,500,000	40,200,000	29,100,000	70,100,000	15.04	54,500,000
November,	1,238,600,000	41,300,000	31,900,000	84,200,000	15.07	54,100,000
December,	1,508,800,000	48,700,000	36,300,000	83,300,000	15.32	54,800,000
January,	1,314,700,000	42,400,000	31,900,000	61,300,000	15.11	54,400,000
February,	1,135,000,000	40,500,000	33,500,000	47,600,000	15.12	57,200,000
March,	1,782,600,000	57,500,000	37,300,000	98,200,000	15.68	64,400,000
April,	2,447,500,000	81,600,000	60,500,000	123,800,000	16.33	68,900,000
May,	2,255,900,000	72,800,000	56,100,000	111,800,000	16.12	65,000,000
June,	1,436,700,000	47,900,000	39,300,000	66,400,000	15.16	58,700,000
July,	1,292,500,000	41,700,000	31,400,000	65,600,000	14.98	55,800,000
August,	1,250,500,000	40,300,000	34,000,000	66,700,000	14.95	55,500,000
September,	1,206,000,000	40,200,000	34,600,000	53,100,000	14.99	55,500,000
October,	1,241,400,000	40,000,000	33,800,000	64,400,000	14.94	55,300,000
November,	1,192,600,000	39,800,000	29,800,000	81,400,000	14.95	52,600,000
December,	1,950,200,000	62,900,000	36,300,000	118,300,000	15.67	60,600,000
Total,	22,498,500,000	-	-	-	-	-
Average,	-	49,200,000	37,000,000	79,700,000	15.30	57,800,000

CHARLESTOWN PUMPING STATION.

At this station are three submerged centrifugal pumps, two of them having impellers or wheels 7.5 feet in diameter, the other 8.25 feet in diameter. They are driven by triple-expansion engines of the Reynolds-Corliss type.

Contract capacity of pumps: two, 22,000,000 gallons each, with 11-foot lift; one, 60,000,000 gallons, with 8-foot lift.
Average duty for the year: 53,500,000 foot-pounds.
Average quantity raised each day: 30,700,000 gallons.
Force employed: 3 engineers, 3 firemen, 6 screenmen and 1 reliefman.
Coal used: first-quality Cumberland, costing from $3.95 to $3.98 per ton.

Table of Approximate Quantities, Lifts and Duties at the Charlestown Pumping Station of the North Metropolitan System.

MONTHS.	Total Pumpage (Gallons).	Average per Day (Gallons).	Minimum Day (Gallons).	Maximum Day (Gallons).	Average Lift (Feet).	Average Duty (ft.-lbs. per 100 lbs. Coal).
1900-1901.						
October,	916,200,000	29,600,000	24,100,000	39,100,000	7.75	57,100,000
November,	851,000,000	28,400,000	20,400,000	41,400,000	7.76	53,200,000
December,	953,600,000	30,800,000	25,800,000	40,700,000	7.90	59,800,000
January,	913,700,000	29,500,000	23,500,000	38,300,000	8.15	60,100,000
February,	802,300,000	28,600,000	23,000,000	32,600,000	7.90	54,000,000
March,	997,700,000	32,200,000	22,800,000	45,500,000	8.22	56,600,000
April,	1,185,800,000	39,500,000	28,800,000	58,900,000	8.69	65,600,000
May,	1,146,100,000	37,000,000	28,300,000	51,000,000	8.37	60,100,000
June,	904,000,000	30,100,000	23,900,000	37,300,000	8.00	52,200,000
July,	874,200,000	28,200,000	22,400,000	38,600,000	7.88	46,600,000
August,	896,500,000	28,900,000	25,900,000	38,500,000	7.96	50,700,000
September,	857,200,000	28,600,000	24,200,000	35,800,000	7.89	47,800,000
October,	852,400,000	27,500,000	21,100,000	37,000,000	7.65	45,600,000
November,	801,600,000	26,700,000	18,200,000	44,500,000	7.65	45,800,000
December,	1,066,300,000	34,400,000	22,300,000	53,600,000	8.04	47,400,000
Total,	14,018,600,000	-	-	-	-	-
Average,	-	30,700,000	23,600,000	42,200,000	7.99	53,500,000

ALEWIFE BROOK PUMPING STATION.

The plant at this station consists of the original installation of small commercial pumps and engines, *i.e.*, two 9-inch Andrews vertical centrifugal pumps, with direct-connected compound marine engines, together with the recent additions. The latter consist of a specially designed engine of the vertical cross-compound type, having between the cylinders a centrifugal pump rotating on a horizontal axis.

Contract capacity of the two original pumps: 4,500,000 gallons each, with 13-foot lift.
Contract capacity of new pump: 13,000,000 gallons, with 13-foot lift.
Average duty for the year: 18,900,000 foot-pounds.
Average quantity raised each day: 3,780,000 gallons.
Force employed: 2 engineers and 1 laborer.
Coal used: first-quality Cumberland, costing from $4.23 to $4.45 per ton.

Table of Approximate Quantities, Lifts and Duties at the Alewife Brook Pumping Station of the North Metropolitan System.

MONTHS.	Total Pumpage (Gallons).	Average per Day (Gallons).	Minimum Day (Gallons).	Maximum Day (Gallons).	Average Lift (Feet).	Average Duty (ft.-lbs. per 100 lbs. Coal).
1900-1901.						
October,	87,699,000	2,829,000	1,784,000	6,813,000	13.30	13,800,000
November,	87,487,000	2,916,000	1,580,000	6,990,000	13.06	15,800,000
December,	115,189,000	3,716,000	2,414,000	5,882,000	13.04	19,600,000
January,	90,051,000	2,905,000	2,330,000	4,376,000	13.26	17,900,000
February,	80,345,000	2,869,000	2,414,000	3,279,000	13.30	17,200,000
March,	130,245,000	4,202,000	2,414,000	7,462,000	12.97	21,300,000
April,	204,306,000	6,810,000	5,105,000	9,350,000	12.88	30,200,000
May,	207,778,000	6,702,000	4,876,000	8,229,000	12.80	28,200,000
June,	128,412,000	4,280,000	2,833,000	6,076,000	13.09	19,800,000
July,	95,805,000	3,090,000	2,246,000	6,400,000	13.31	15,600,000
August,	91,671,000	2,957,000	2,162,000	5,882,000	13.11	14,000,000
September,	88,012,000	2,934,000	2,246,000	4,376,000	13.10	14,500,000
October,	89,770,000	2,896,000	2,204,000	5,300,000	13.09	15,000,000
November,	88,456,000	2,948,000	1,700,000	6,076,000*	12.97	17,500,000
December,	144,201,000	4,652,000	2,228,000	8,052,000	13.08	23,000,000
Total,	1,729,422,000	-	-	-	-	-
Average,	-	3,780,000	2,536,000	6,303,000	13.09	18,900,000

* Exclusive of days when tide water was pumped for engine testing purposes.

QUINCY PUMPING STATION.

[Operated by the Commonwealth since April 1, 1901.]

At this station are two compound condensing Deane pumping engines.

Contract capacity of pumps: one, 3,000,000 gallons, the other, 5,000,000 gallons, with 36-foot lift.
Average duty for the year: 26,900,000 foot-pounds.
Average quantity raised each day: 2,014,000 gallons.
Force employed: 3 engineers.
Coal used: first-quality Cumberland, costing from $4.25 to $4.75 per ton.

Table of Approximate Quantities, Lifts and Duties at the Quincy Pumping Station of the South Metropolitan System.

MONTHS.	Total Pumpage (Gallons).	Average per Day (Gallons).	Minimum Day (Gallons).	Maximum Day (Gallons).	Average Lift (Feet).	Average Duty (ft.-lbs. per 100 lbs. Coal).
1901.						
April,	85,800,000	2,860,000	2,327,000	3,743,000	42.32	33,000,000
May,	81,489,000	2,629,000	2,226,000	3,242,000	41.06	31,000,000
June,	62,239,000	2,075,000	1,668,000	2,585,000	37.38	29,300,000
July,	53,819,000	1,736,000	1,481,000	2,074,000	33.68	25,000,000
August,	47,682,000	1,538,000	1,361,000	1,785,000	32.48	23,400,000
September,	45,842,000	1,528,000	1,313,000	2,080,000	32.23	23,500,000
October,	53,263,000	1,718,000	1,420,000	2,207,000	32.04	24,700,000
November,	49,945,000	1,665,000	1,381,000	2,061,000	33.45	24,100,000
December,	73,778,000	2,380,000	1,630,000	4,348,000	36.58	28,000,000
Total,	553,857,000	-	-	-	-	-
Average,	-	2,014,000	1,645,000	2,675,000	35.69	26,900,000

In the following tables the total cost of pumping and the rate per million foot-gallons at each of the five pumping stations are shown in detail: —

Average Cost per Million Foot-gallons for Pumping at the Deer Island Station.

Volume (23,782.3 Million Gallons) × Lift (11.47 Feet) = 272,783 Million Foot-gallons.

ITEMS.	Cost.	Cost per Million Foot-gallons.
Labor,	$12,401 12	$0.04547*
Coal,	7,553 61	.02769
Oil,	262 13	.00096
Waste,	32 91	.00012
Water,	1,740 40	.00638
Packing,	85 41	.00031
Miscellaneous supplies and renewals,	1,467 61	.00538
Total,	$23,543 19	$0.08631

* Includes labor at screens; deducting this item gives cost of labor $0.03032. Deducting labor at screens gives cost of pumping $0.07116.

Average Cost per Million Foot-gallons for Pumping at the East Boston Station.

Volume (22,498.5 Million Gallons) × Lift (15.3 Feet) = 344,227 Million Foot-gallons.

ITEMS.	Cost.	Cost per Million Foot-gallons.
Labor,	$11,969 67	$0.03477*
Coal,	9,005 14	.02616
Oil,	202 80	.00059
Waste,	49 64	.00014
Water,	1,042 30	.00303
Packing,	74 72	.00022
Miscellaneous supplies and renewals,	1,845 04	.00536
Total,	$24,188 81	$0.07027

* Includes labor at screens; deducting this item gives cost of labor $0.02351. Deducting labor at screens gives cost of pumping $0.05901.

Average Cost per Million Foot-gallons for Pumping at the Charlestown Station.

Volume (14,018.6 Million Gallons) × Lift (7.99 Feet) = 112,009 Million Foot-gallons.

ITEMS.	Cost.	Cost per Million Foot-gallons.
Labor,	$11,180 58	$0.09981*
Coal,	3,433 19	.03065
Oil,	233 25	.00208
Waste,	86 24	.00077
Water,	493 60	.00443
Packing,	199 72	.00178
Miscellaneous supplies and renewals,	829 90	.00741
Total,	$16,456 48	$0.14693

* Includes labor at screens; deducting this item gives cost of labor $0.06660. Deducting labor at screens gives cost of pumping $0.11872.

Average Cost per Million Foot-gallons for Pumping at the Alewife Brook Station.

Volume (1,729.4 Million Gallons) × Lift (13.09 Feet) = 22,638 Million Foot-gallons.

ITEMS.	Cost.	Cost per Million Foot-gallons.
Labor,	$3,690 89	$0.16305
Coal,	1,939 25	.08567
Oil,	228 61	.01010
Waste,	29 51	.00130
Water,	358 98	.01586
Packing,	29 40	.00130
Miscellaneous supplies and renewals,	178 84	.00790
Total,	$6,455 48	$0.28518

Average Cost per Million Foot-gallons for Pumping at the Quincy Station.

Volume (553.86 Million gallons) × Lift (35.69 Feet) = 19,767 Million Foot-gallons.

ITEMS.	Cost.	Cost per Million Foot-gallons.
Labor,	$2,476 47	$0.12528
Coal,	1,268 73	.06418
Oil,	33 19	.00168
Waste,	6 22	.00031
Water,	82 56	.00418
Packing,	21 46	.00109
Miscellaneous supplies and renewals,	525 08	.02656
Total,	$4,413 71	$0.22328

MATERIAL INTERCEPTED AT THE SCREENS.

At the three main line stations the sewage, before reaching the pumps, is passed through cages, set in pairs in the lower sewer and raised or lowered by steam power.

The total amount of material, consisting of paper, rags and other miscellaneous matter, intercepted at the screens of the main line stations of the North Metropolitan System, during the fifteen months under review, was about 1,500 cubic yards, or about 1.7 cubic feet per million gallons pumped at Deer Island.

CARE OF SPECIAL STRUCTURES.

Studies of the flow in the Metropolitan sewers, siphons and outfall pipes indicate that these are free from deposit and in a satisfactory condition.

Respectfully submitted,

WM. M. BROWN,
Engineer, Metropolitan Sewerage Works.

BOSTON, December 31, 1901.

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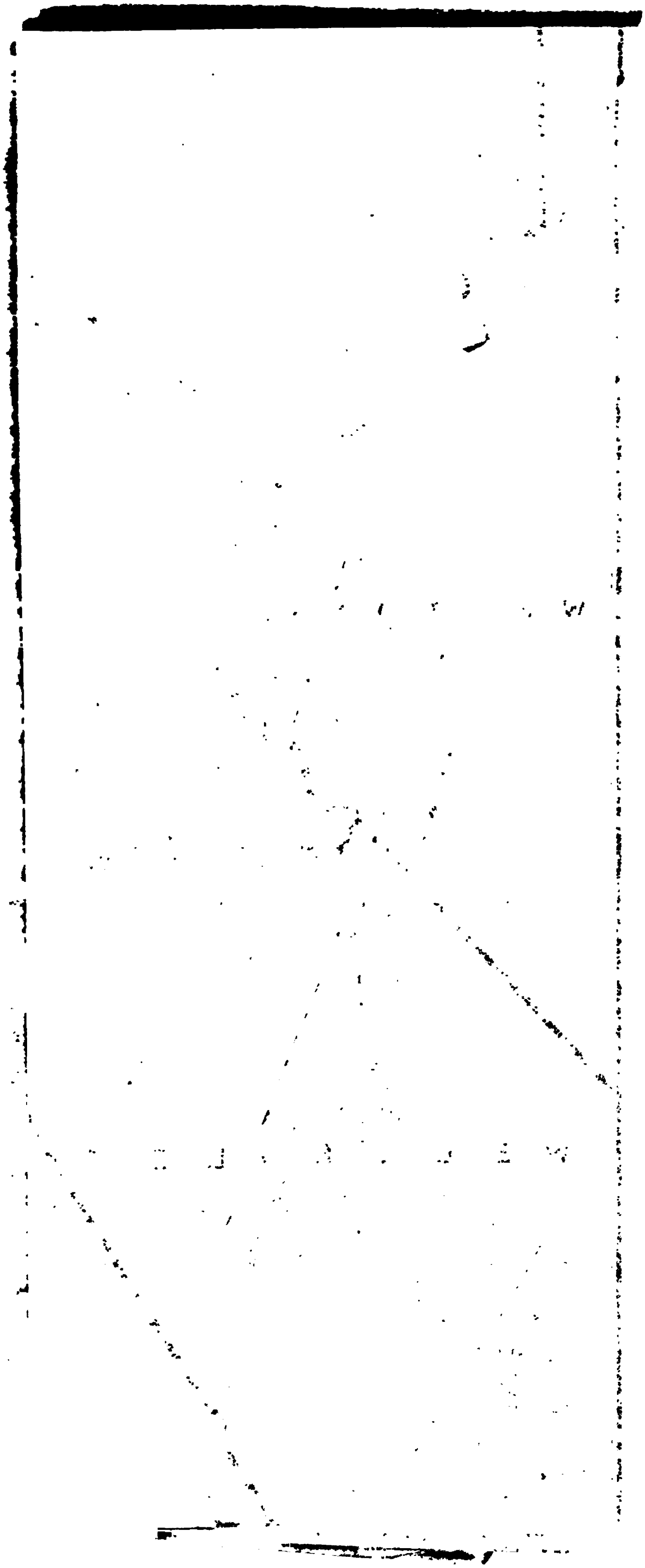

APPENDIX.

APPENDIX No. 1.

CONTRACTS MADE AND PENDING DURING

Contracts relating to the

[NOTE. — The details of contracts made before

	1. Number of Contract.	2. WORK.	3. Number of Bids.	AMOUNT OF BID. 4. Next to Lowest.	5. Lowest.	6. Contractor.
1	150†	Excavating soil, . .	9	$116,831 00	$116,546 00*	Moulton & O'Mahoney,
2	166	Excavating soil, . .	6	1,248,400 00	1,096,300 00*	Nawn & Brock, . .
3	183	Excavating soil, . .	5	238,500 00*	230,685 00	Long & Little, . .
4	210	Excavating soil from Section 8 of the Wachusett Reservoir, and completing the westerly portion of the North Dike, Clinton, Boylston and Sterling, Mass.	3	377,830 00	360,870 00*	Newell & Snowling Construction Company, Uxbridge, Mass.
		Total, ...	. .	. . .	. . .	. . . .

Contracts relating to the

5	195	Wachusett Dam, . .	11	$1,680,870 00	$1,603,635 00*	McArthur Bros. Company.
6	223	78 tons special castings, .	2	7,416 65	6,651 56*	Camden Iron Works, Camden, N. J.
7	Special Order.	Furnishing 8 24-inch and 4 48-inch flange-end water valves and 4 48-inch bell-end water valves.	2	16,528 00	14,512 00*	Chapman Valve Manufacturing Company, Indian Orchard, Mass.
8	Special Order.	13.5 tons special castings,	1	-	1,014 00*	Taunton Locomotive Manufacturing Company, Taunton, Mass.
		Total, ...	. .	. . .	. . .	. . . .

Contracts relating to the

9	3-M.†	Steel stairway, ...	2	$1,498 00	$1,165 00*	G. P. Bullard & Co., .
10	214	Excavating mud and earth from that portion of Lake Cochituate known as Snake Brook Meadow, in Wayland and Natick, building embankments and facing them with gravel.	8	17,225 00	16,850 00*	Long & Little, Leominster, Mass.
		Total, ...	. .	. . .	. . .	. . . .

* Contract based upon this bid. † Contract completed.

Appendix No. 1.

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the Year 1901 — Water Works.

Reservoir Department.

1901 have been given in previous reports.]

7. Date of Contract.	8. Date for Completion of Contract.	9. Date of Final Estimate.	10. Prices of Principal Items of Contracts made in 1901.	11. Amount of Contract.	12. Value of Work done Dec. 31, 1901.	
April 10, '99,	June 1, '00,	Jan. 21, '01,	- -	$157,130 37	$157,130 37	1
June 13, '99,	Dec. 1, '02,	-	- -	1,096,300 00	727,900 00	2
Dec. 12, '99,	July 1, '03,	-	- -	238,500 00	174,400 00	3
Aug. 1, '01,	Nov. 1, 04,	-	For clearing and grubbing, $55 per acre; for soil excavation, $0.27, $0.33, $0.37 and $0.39 per cu. yd.; for earth excavation, $0.22 and $0.18 per cu. yd.; for gravel excavation, $0.27 per cu. yd.	360,870 00	39,700 00	4
. . .	. . .	. . .	. . . .	$1,852,800 37	$1,099,130 37	

Dam and Aqueduct Department.

Oct. 1, '00,	Nov. 15, '04,	-	- -	$1,603,635 00	$190,218 24	5
Nov. 25, '01,	June 1, '02,	-	$85.20 per ton of 2,000 lbs., delivered at Berlin, Mass.	6,651 56	-	6
Nov. 27, '01,	April 15, '02,	-	24-inch valves, $446 each; 48-inch flange-end valves, $1,636 each; 48-inch bell-end valves, $1,100 each.	14,512 00	-	7
Dec. 14, '01,	April 15, '02,	-	$75 per ton of 2,000 lbs., delivered at Berlin, Mass.	1,014 00	-	8
. . .	. . .	. . .	. . . .	$1,625,812 56	$190,218 24	

Sudbury Department.

Oct. 19, '00,	Dec. 1, '00,	April 18, '01,	- -	$1,323 20	$1,323 20	9
Sept. 11, '01,	Dec. 15, '01,	-	For mud and earth excavation, $0.24 per cu. yd.; for gravel excavation, $0.25 per cu. yd.	14,000 00	12,000 00	10
. . .	. . .	. . .	. . . .	$15,323 20	$13,323 20	

CONTRACTS MADE AND PENDING DURING THE

Contracts relating to the

	1. Number of Contract.	2. WORK.	3. Number of Bids.	AMOUNT OF BID. 4. Next to Lowest.	5. Lowest.	6. Contractor.
1	199	Section 2, Weston Aqueduct, 3,700 feet in tunnel, 4,755 feet in open trench.	8	$234,581 50	$200,477 00*	Shanahan, Casparis & Co , Louisville, Ky., and Columbus, O.
2	200	Section 3, Weston Aqueduct, 2,150 feet in tunnel, 3,350 feet in open trench.	9	131,226 10	127,507 50*	Shanahan, Casparis & Co., Louisville, Ky., and Columbus, O.
3	201	Section 4, Weston Aqueduct, 4,155 feet in open trench.	19	68,810 50	64,888 50*	Patrick McGovern, Boston, Mass.

* Contract based upon this bid.

YEAR 1901 — WATER WORKS — *Continued.*

Weston Aqueduct Department.

7. Date of Contract.	8. Date for Completion of Contract.	9. Date of Final Estimate.	10. Prices of Principal Items of Contracts made in 1901.	11. Amount of Contract.	12. Value of Work done Dec. 31, 1901.	
May 9, '01,	Aug. 1, '03,	-	For earth excavation, $0.37 per cu. yd.; for rock excavation, $1.40 per cu. yd.; for excavation from tunnels: No. 1, $2.60 per cu. yd.; No, 2, $5.25 per cu. yd.; for brick masonry, laid in natural cement mortar: in open trench, $11.75 per cu. yd.; in tunnel, $12 per cu yd.; for natural cement concrete masonry in open trench, $4 per cu. yd.; for Portland cement concrete masonry: in open trench, $5.50 per cu. yd.; lining in tunnel, $6.25 and $5.75 per cu. yd.; for dimension stone masonry, laid in mortar, $37 per cu. yd.; for face dressing of pointed work, $0.40 per sq. ft.; for dry rubble stone masonry, $3 per cu. yd.; for dry rubble stone paving, $1.90 per cu. yd.	$200,477 00	$46,090 00	1
May 9, '01,	Aug. 1, '03,	-	For earth excavation, $0.32 per cu. yd.; for rock excavation, $1.40 per cu. yd.; for excavation from tunnel, $5.25 per cu. yd.; for brick masonry, laid in natural cement mortar, $11.75 per cu. yd.; for natural cement concrete masonry in open trench, $4 per cu. yd.; for Portland cement concrete masonry: in open trench, $5.50 per cu. yd.; lining in tunnel, $6.25 and $5.75 per cu. yd.; for dimension stone masonry laid in mortar, $37 per cu. yd.; for face dressing of pointed work, $0.40 per sq. ft.; for dry rubble stone masonry, $3 per cu. yd.; for dry rubble stone paving, $1 90 per cu. yd.	127,507 50	27,594 00	2
May 6, '01,	Aug. 1, '03,	-	For earth excavation, $0.27 per cu. yd.; for borrowed earth, $0.23 per cu. yd.; for rock excavation, $2.10 per cu. yd.; for brick masonry, laid in natural cement mortar, $11.25 per cu. yd.; for natural cement concrete masonry, $3.90 per cu. yd.; for Portland cement concrete masonry, $5.25 per cu. yd.; for dimension stone masonry, laid in mortar, $50 per cu. yd.; for face dressing of pointed work, $0.25 per sq. ft.; for dry rubble stone masonry, $3.50 per cu. yd.; for dry rubble stone paving, $2 per cu. yd.	64,888 50	46,926 00	3

CONTRACTS MADE AND PENDING DURING

Contracts relating to the

	1.	2.	3.	Amount of Bid.		6.
	Number of Contract.	WORK.	Number of Bids.	4. Next to Lowest.	5. Lowest.	Contractor.
1	202	Section 5, Weston Aqueduct, 5,295 feet in open trench, including a railroad crossing.	16	$139,023 00	$137,526 50*	Bruno, Salomone & Petitti, Boston, Mass.
2	203	Section 6, Weston Aqueduct, 4,520 feet in open trench, including siphon chamber.	14	121,497 00	120,646 50*	Shanahan, Casparis & Co., Louisville, Ky., and Columbus, O.
3	204	Section 12, Weston Aqueduct, 6,500 feet in open trench.	16	139,197 50	134,096 50*	Shanahan, Casparis & Co., Louisville, Ky., and Columbus, O.

* Contract based upon this bid.

THE YEAR 1901 — WATER WORKS — *Continued.*

Weston Aqueduct Department — Continued.

7. Date of Contract.	8. Date for Completion of Contract.	9. Date of Final Estimate.	10. Prices of Principal Items of Contracts made in 1901.	11. Amount of Contract.	12. Value of Work done Dec. 31, 1901.	
May 8, '01,	Aug. 1, '03,	-	For earth excavation, $0.27 per cu. yd.; for borrowed earth, $0.20 per cu. yd.; for rock excavation, $1 per cu. yd.; for brick masonry laid in natural cement mortar, $11.50 per cu. yd.; for natural cement concrete masonry, $4.70 per cu. yd.; for Portland cement concrete masonry, $5.30 per cu. yd.; for dimension stone masonry, laid in mortar, $20 per cu. yd.; for face dressing of pointed work, $0.25 per sq. ft.; for dry rubble stone masonry, $4 per cu. yd.; for dry rubble stone paving, $4 per cu. yd.; for railroad crossing, $200.	$137,526 50	$51,480 00	1
May 9, '01,	Aug. 1, '03,	-	For earth excavation, $0.35 per cu. yd.; for borrowed earth, $0.25 per cu. yd.; for rock excavation, $1.50 per cu. yd.; for brick masonry, laid in natural cement mortar, $11.50 per cu. yd.; for natural cement concrete masonry, $4 per cu. yd.; for Portland cement concrete masonry, $5.50 per cu. yd.; for dimension stone masonry, laid in mortar, $35 per cu. yd.; for face dressing of pointed work, $0.40 per sq. ft.; for dry rubble stone masonry, $3 per cu. yd.; for dry rubble stone paving, $1.90 per cu. yd.	120,646 50	24,151 00	2
May 9, '01,	Aug. 1, '03,	-	For earth excavation, $0.24 per cu. yd.; for borrowed earth, $0.19 per cu. yd.; for rock excavation, $1.50 per cu. yd.; for brick masonry, laid in natural cement mortar, $11.25 per cu. yd.; for natural cement concrete masonry, $3.55 per cu. yd.; for Portand cement concrete masonry, $5.10 per cu. yd.; for dimension stone masonry, laid in mortar, $35 per cu. yd.; for face dressing of pointed work, $0.40 per sq. ft.; for dry rubble stone masonry, $3 per cu. yd.; for dry rubble stone paving, $1.90 per cu. yd.	134,096 50	32,475 00	3

CONTRACTS MADE AND PENDING DURING

Contracts relating to the

	1. Number of Contract.	2. WORK.	3. Number of Bids.	AMOUNT OF BID. 4. Next to Lowest.	5. Lowest.	6. Contractor.
1	205	Section 13, Weston Aqueduct, 5,600 feet in tunnel, 1,700 feet in open trench.	9	$364,884 00	$346,290 00*	Michael H. Keefe, Yonkers, N. Y. Assigned on Oct. 12, 1901, to Columbus Construction Co., New York, N. Y.
2	208	Castings for siphon chamber.	4	11,840 00	10,908 00*	Henry R. Worthington, New York, N. Y.
3	211	Sections 8 and 10, Weston Aqueduct, 6,390 feet in open trench, including 3 siphon chambers.	11	155,508 50	146,189 00*	Winston & Co., Clinton, Mass.

* Contract based upon this bid.

THE YEAR 1901 — WATER WORKS — *Continued.*

Weston Aqueduct Department — Continued.

7. Date of Contract.	8. Date for Completion of Contract.	9. Date of Final Estimate.	10. Prices of Principal Items of Contracts made in 1901.	11. Amount of Contract.	12. Value of Work done Dec. 31, 1901.	
May 20, '01,	Aug. 1, '03,	-	For earth excavation, $0.60 per cu. yd.; for borrowed earth, $0.25 per cu. yd.; for rock excavation $0.80 per cu. yd.; for excavation from tunnel, $6 per cu. yd.; for brick masonry in open trench, laid in natural cement mortar, $12 per cu. yd.; for natural cement concrete masonry, in open trench, $5 per cu. yd.; for Portland cement concrete masonry: in open trench, $6 per cu. yd., for lining in tunnel, $6.25 and $5 per cu. yd.; for dimension stone masonry, laid in mortar, $30 per cu. yd.; for face dressing of pointed work, $0.50 per sq. ft.; for dry rubble stone masonry, $2.50 per cu. yd.; for dry rubble stone paving, $2 per cu. yd.	$346,290 00	$46,065 00	1
May 21, '01,	April 1, '02,	-	For 12 sets castings, $10,908,	10,908 00	2,730 00	2
Aug. 28, '01,	Aug. 1, '03,	-	For earth excavation, $0.30 per cu. yd.; for borrowed earth, $0.18 per cu. yd.; for rock excavation, $1.75 per cu. yd.; for brick masonry, laid in natural cement mortar, $11 per cu. yd.; for natural cement concrete masonry, $3.85 per cu. yd.; for Portland cement concrete masonry, $5.30 per cu. yd.; for dimension stone masonry, laid in mortar, $50 per cu. yd.; for face dressing of pointed work, $0.60 per sq. ft.; for dry rubble stone masonry, $4 per cu. yd.; for dry rubble stone paving, $4 per cu. yd.	146,189 00	11,351 00	3

CONTRACTS MADE AND PENDING DURING

Contracts relating to the

	1.	2.	3.	Amount of Bid.		6.
	Number of Contract.	WORK.	Number of Bids.	4. Next to Lowest.	5. Lowest.	Contractor.
1	212	Section 11, Weston Aqueduct, 6,600 feet in trench.	10	$157,270 00	$148,685 00*	Winston & Co., Clinton, Mass.
2	213	Section 15, Weston Aqueduct, 600 feet in tunnel, 5,125 feet in open trench, also excavation from portion of Weston Reservoir and construction of portion of dam and drain.	5	197,556 00	171,645 00*	Winston & Co., Clinton, Mass.
3	218	Section 14, Weston Aqueduct, open channel and upper portion of reservoir.	10	68,364 00	58,490 00*	Nawn & Brock, Boston, Mass.

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* Contract based upon this bid.

THE YEAR 1901 — WATER WORKS — *Continued.*

Weston Aqueduct Department — Continued.

7. Date of Contract.	8. Date for Completion of Contract.	9. Date of Final Estimate.	10. Prices of Principal Items of Contracts made in 1901.	11. Amount of Contract.	12. Value of Work done Dec. 31, 1901.	
Aug. 28, '01,	Aug. 1, '03,	-	For earth excavation, $0.32 per cu. yd.; for borrowed earth, $0.25 per cu. yd.; for rock excavation, $1.50 per cu. yd.; for brick masonry, laid in natural cement mortar, $11 per cu. yd.; for natural cement concrete masonry, $3.80 per cu. yd.; for Portland cement concrete masonry, $5.30 per cu. yd.; for dimension stone masonry, laid in mortar, $50 per cu. yd.; for face dressing of pointed work, $0.60 per sq. ft.; for dry rubble stone masonry, $4 per cu. yd.; for dry rubble stone paving, $4 per cu. yd.	$148,635 00	-	1
Aug. 28, '01,	Aug. 1, '03,	-	For earth excavation: in open trench, $0.42 per cu. yd., in reservoir, $0.37 per cu. yd.; for borrowed earth, $0.32 per cu. yd.; for rock excavation, $1.40 per cu. yd.; for excavation from tunnel, $5 per cu. yd.; for brick masonry, in open trench, laid in natural cement mortar, $11 per cu. yd.; for natural cement concrete masonry, in open trench, $3 80 per cu. yd.; for Portland cement concrete masonry: in open trench, $5.10 per cu. yd., for lining in tunnel, $7 and $6 per cu. yd.; for dimension stone masonry, laid in mortar, $30 per cu. yd.; for face dressing of pointed work, $0.55 per sq. ft.; for dry rubble stone masonry, $3 per cu. yd.; for dry rubble stone paving, $3 per cu. yd.	171,645 00	$4,384 00	2
Nov. 26, '01,	Aug. 1, '03,	-	For earth excavation, $0.23 per cu. yd.; for rock excavation, $1.50 per cu. yd.; for riprap, $1 per cu. yd.; for slope paving, $2 per cu. yd.; for Portland cement concrete masonry, $5 and $5.50 per cu. yd.; for ashlar masonry, $18 per cu. yd.; for dimension stone masonry, $30 per cu. yd.; for face dressing of pointed work, $0.40 per sq. ft.; for laying 36-inch cast-iron pipe, $1 per lin. ft.	58,490 00	-	3

CONTRACTS MADE AND PENDING DURING

Contracts relating to the

	1. Number of Contract.	2. WORK.	3. Number of Bids.	Amount of Bid. 4. Next to Lowest.	Amount of Bid. 5. Lowest.	6. Contractor.
1	219	Section 1 of the Weston Reservoir, central portion.	11	$64,971 25	$59,587 50*	Nawn & Brock, Boston, Mass.
2	220	Section 2 of the Weston Reservoir, lower portion of reservoir, including dam and concrete drain.	9	90,152 50	88,292 50*	Nawn & Brock, Boston, Mass.
3	Special Order.†	19 tons 16-inch and 12 tons 12-inch cast-iron water pipe, and 2 tons special castings.	3	777 00	768 90*	United States Cast Iron Pipe and Foundry Company, Philadelphia, Pa.
		Total, ...	. .	. . .	. . .	. . . .

Contracts relating to the

4	72†	3 pumping engines, . .	5	$195,000 00	$136,500 00*	Holly Manufacturing Company.
5	122†	Pumping engine, . .	4	64,000 00	62,500 00*	Holly Manufacturing Company.
6	126†	Low-service pumping station.	9	193,050 00	182,659 50*	Norcross Bros, . .
7	137†	Spot Pond pumping station.	10	110,822 50	108,480 00*	McNeil Bros., . .
8	171†	8 sluice gates, . . .	8	10,639 00	8,986 00*	The Atlantic Works, .
9	185†	Gate-house, . . .	9	10,399 00	9,974 00*	John S. Jacobs & Son,
10	192†	Forbes Hill Reservoir, .	13	36,355 00	34,736 00*	Beckwith & Quackenbush.
11	194†	Forbes Hill standpipe, .	4	4,498 00	4,425 00*	Walsh's Holyoke Steam Boiler Works.
12	196†‡	Tunnel under Mystic River.	1	-§	-§	Charles A. Haskin, .
13	1-M.†‡	Tubular boilers, . .	2	6,550 00	4,900 00*	Lake Erie Boiler Works.
14	206	Masonry water tower on Forbes Hill, Quincy, Mass.	4	24,973 00	24,790 00*	J. E. McCoy, Boston, Mass.

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* Contract based upon this bid.

† Contract completed.

‡ This contract charged to maintenance.

§ Competitive bids were not received on this contract.

THE YEAR 1901 — WATER WORKS — *Continued.*

Weston Aqueduct Department — Concluded.

7. Date of Contract.	8. Date for Completion of Contract.	9. Date of Final Estimate.	10. Prices of Principal Items of Contracts made in 1901.	11. Amount of Contract.	12. Value of Work done Dec. 31, 1901.	
Nov. 26, '01,	Aug. 1, '03,	-	For earth excavation, $0.25 per cu. yd ; for rock excavation, $1.50 per cu. yd.; for riprap, $1 per cu. yd.; for furnishing and laying 18 and 20 inch sewer pipe for drains and culvert, $2.50 per lin. ft.	$59,587 50	-	1
Nov. 26, '01,	Aug. 1, '03,	-	For clearing and grubbing, $100 per acre; for earth excavation, $0.29, $0.34 and $0.80 per cu. yd.; for rock excavation, $1.30 and $2.50 per cu. yd.; for riprap, $1 per cu. yd.; for slope paving, $2.50 per cu. yd.; for Portland cement concrete masonry, $5 and $5 50 per cu. yd.; for dimension stone masonry, $40 per cu. yd.; for face dressing of pointed work, $0.50 per sq. ft.; for laying 16-inch cast-iron pipe, $0 75 per lin. ft.	88,292 50	-	2
May 9, '01,	-	June 19, '01,	Pipes, $21.90, special castings, $45, per ton of 2,000 lbs.	792 23	$792 23	3
. . .	. . .	. . .	. . . .	$1,815,921 73	$294,038 23	

Distribution Department.

Oct. 20, '97,	July 20, '99,	Sept. 11, '01,	- -	$150,784 62	$150,784 62	4
Sept. 20, '98,	Jan. 20, '00,	Nov. 6, '01,	- -	78,139 38	78,139 38	5
Aug. 26, '98,	July 15, '99,	May 2, '01,	- -	200,549 82	200,549 82	6
Jan. 7, '99,	Dec. 15, '99,	May 24, '01,	- -	122,181 08	122,181 08	7
June 23, '99,	Jan. 1, '00,	July 31, '01,	- -	9,262 00	9,262 00	8
April 21, '00,	Oct. 1, '00,	June 4, '01,	- -	9,974 00	9,974 00	9
July 7, '00,	Dec. 1, '00,	Dec. 24, '01,	- -	37,253 61	37,253 61	10
July 20, '00,	Nov. 1, '00,	Jan. 15, '01,	- -	4,529 72	4,529 72	11
Aug. 2, '00,	Nov. 1, '00,	Mar. 6, '01,	- -	20,507 81	20,507 81	12
Sept. 26, '00,	Nov. 15, '00,	July 25, '01,	- -	4,900 00	4,900 00	13
May 23, '01,	Nov. 1, '01,	-	For whole work, $24,790, .	24,790 00	15,500 00	14

CONTRACTS MADE AND PENDING DURING

Contracts relating to the

1. Number of Contract.		2. WORK.	3. Number of Bids.	AMOUNT OF BID. 4. Next to Lowest.	AMOUNT OF BID. 5. Lowest.	6. Contractor.
1	207†	Laying water pipes in Stoneham, Mass., Section 29 of the distribution system.	6	$22,646 10	$20,907 50*	The C. H. Eglee Company, Boston, Mass.
2	209	Bear Hill Reservoir in Stoneham, Mass.	6	19,456 00*	16,950 00	The C. H. Eglee Company, Boston, Mass.
3	215†	Connection chamber at Chestnut Hill.	3	1,658 00	1,562 00*	Norcross Bros., Boston, Mass.
4	216	8,900 tons cast-iron water pipes, 7,500 tons 48-inch, 1,100 tons 60-inch, 100 tons special castings.	2	48-inch pipes, $25.80 per ton; special castings, $60 per ton.‡	48-inch pipes, $22.87 per ton; special castings, $59 per ton.*	United States Cast Iron Pipe and Foundry Company, New York, N. Y.
5	217	8,950 tons cast-iron water pipes, 5,500 tons 48-inch, 3,350 tons 60-inch, 100 tons special castings §	1	-	48-inch pipe, $23.87 per ton; 60-inch pipe, $26.90 per ton: special castings, $75 per ton.*	United States Cast Iron Pipe and Foundry Company, New York, N. Y.
6	221	39 water valves, 10 36-inch, 8 24-inch, 6 16-inch, 15 12-inch.	4	12,650 00	11,940 00*	Geo. F. Blake Manufacturing Company, New York, N. Y.
7	222	284 tons special castings,§	2	23,727 64	22,894 25*	Geo. F. Blake Manufacturing Company, New York, N. Y.
8	Special Order.†	50 tons 12-inch cast-iron water pipes.	3	1,080 00	1,075 00*	United States Cast Iron Pipe and Foundry Company, New York, N. Y.
9	Special Order.†	5 20-inch water gates, .	2	1,500 00	1,075 00*	Coffin Valve Company, Boston, Mass.
10	Special Order.†	Hydraulic cylinder for 36-inch valve and 16-inch check valve.	1	-	1,099 00*	Coffin Valve Company, Boston, Mass.
11	Special Order.†	Furnishing and erecting 3 20-inch sluice gates and 1 12-inch sluice gate.	2	1,372 00	1,010 00*	Coffin Valve Company, Boston, Mass.
		Total, ...	. .	. . .	. . .	. . . .

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* Contract based upon this bid. † Contract completed.

‡ Bid did not conform with specifications regarding time of delivery, and was informal.

§ Includes pipes and castings supplied to other departments.

THE YEAR 1901 — WATER WORKS — *Continued.*

Distribution Department — Concluded.

7. Date of Contract.	8. Date for Completion of Contract.	9. Date of Final Estimate.	10. Prices of Principal Items of Contracts made in 1901.	11. Amount of Contract.	12. Value of Work done Dec. 31, 1901.	
June 22, '01,	Sept. 15, '01,	Dec. 11, '01,	For laying cast-iron pipe: 24-inch, $1.30 per lin. ft., 20-inch, $1.08 per lin. ft.; for laying cable, $0.05 per lin. ft.; for rock excavation, above grade, $3 per cu. yd.; for brick chambers: for 20-inch valves, $50 each; for small valves, $30 each.	$20,450 12	$20,450 12	1
July 16, '01,	Nov. 15, '01,	-	For earth excavation, $0.40 per cu. yd ; for rock excavation, $1.95 per cu. yd.; for Portland cement concrete masonry, $7 per cu. yd.; for paving set in mortar, $8 per cu. yd.; for riprap, $1.50 per cu. yd.; for granite dimension stone masonry, $50 per cu. yd.	19,456 00	17,720 21	2
July 5, '01,	-	Oct. 24, '01,	For building complete, $1,552.	1,552 00	1,552 00	3
Nov. 21, '01,	Dec. 1, '02,	-	48-inch pipe, $22.87; 60-inch pipe, $26.90; special castings, $59 per ton of 2,000 lbs., delivered in Newton, Mass.	213,876 00	-	4
Nov. 21, '01,	Dec. 1, '02,	-	48-inch pipe, $23.87; 60-inch pipe, $26.90; special castings, $75 per ton of 2,000 lbs., delivered at Glenwood, Newton, Fayville and Berlin, Mass.	231,317 30	-	5
Nov. 30, '01,	Aug. 30, '02,	-	36-inch valves, $678; 24-inch valves, $273; 16-inch valves, $161; 12-inch valves, $134.	11,940 00	-	6
Nov. 25, '01,	Sept. 1, '02,	-	$78 to $88 per ton of 2,000 lbs., delivered at Glenwood, Newton, Fayville and Berlin, Mass.	22,894 25	-	7
April 18, '01,	May 1, '01,	June 5, '01,	$21.50 per ton of 2,000 lbs., .	1,075 00	1,077 72	8
May 16, '01,	-	Oct. 2, '01,	$215 each, ...	1,075 00	1,075 00	9
July 8, '01,	-	Oct. 18, '01,	Hydraulic cylinder, $950; 16-inch check valve, $149.	1,099 00	1,099 00	10
July 15, '01,	-	Dec. 4, '01,	20-inch sluice gates, $273 each; 12-inch sluice gate, $191.	1,010 00	1,010 00	11
. . .	. . .	. . .	. . . .	$1,188,616 71	$697,566 09	

CONTRACTS MADE AND PENDING DURING THE YEAR 1901 — WATER WORKS — *Concluded.*

Summary of Contracts.*

	Approximate Amount of Contracts.	Value of Work done December 31, 1901.
Wachusett Reservoir, 4 contracts,	$1,852,808 37	$1,088,130 37
Wachusett Dam, 2 contracts,	1,610,296 56	190,218 24
Sudbury Department, 1 contract,	14,000 00	12,000 00
Weston Aqueduct and Reservoir, 14 contracts,	1,815,120 50	288,246 00
Distribution Department, 16 contracts,	1,158,940 90	683,896 56
Total of 37 contracts made and pending during the year 1901,	$6,451,166 33	$2,262,491 17
194 contracts completed in 1896, 1897, 1898, 1899 and 1900,	6,862,991 67	6,862,991 67
	$13,314,158 00	$9,125,482 84
Deduct for work done on 11 Sudbury Reservoir contracts by the city of Boston,	512,000 00	512,000 00
Total of 231 contracts,	$12,802,158 00	$8,613,482 84

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* In this summary, contracts charged to maintenance are excluded.

APPENDIX No. 2.

CEMENT TESTS.

The following tables contain: —

1. Long-time tests of cements used by the Dam and Aqueduct and Reservoir departments during the years 1896 to 1900, inclusive. The tests for shorter periods were published in Appendix No. 3 of the last annual report of the Metropolitan Water Board, and are omitted this year.

2. All tests of cement used in the construction of the Wachusett Dam during the year 1901.

3. Tests of all cements used in the construction of the Weston Aqueduct during the year 1901.

The methods of testing were the same as described in Appendix No. 3 of the report of the Metropolitan Water Board for the year 1897.

Tabulation of Cement Tests for All Brands of Natural Cement, of which Nine Hundred Barrels or More were used on Construction Work by the Dam and Aqueduct and Reservoir Departments from 1896 to 1900, Inclusive.

BRAND.	Number of Barrels used.	Composition of Briquette.	TENSILE STRENGTH.					
			TWO YEARS.		THREE YEARS.		FIVE YEARS.	
			Number of Briquettes.	Pounds per Square Inch.	Number of Briquettes.	Pounds per Square Inch.	Number of Briquettes.	Pounds per Square Inch.
Beach,	8,380	Neat,	64	467	50	482	-	-
		1 to 1,	64	316	50	349	-	-
Hoffman,	45,345	Neat,	106	467	82	497	13	518
		1 to 1,	106	327	82	347	13	381
Norton,	60,877	Neat,	60	440	54	456	-	-
		1 to 1,	60	295	54	314	-	-
Union,	900	Neat,	22	409	10	474	-	-
		1 to 1,	22	570	10	617	-	-
Total,	115,502	Neat,	252	456	196	480	13	518
		1 to 1,	252	338	196	352	13	381

Tabulation of Cement Tests for All Brands of Portland Cement, of which Nine Hundred Barrels or More were used on Construction Work by the Dam and Aqueduct and Reservoir Departments from 1896 to 1900, Inclusive.

BRAND.	Number of Barrels used.	Composition of Briquette.	Tensile Strength.							
			Eighteen Months.		Two Years.		Three Years.		Five Years.	
			Number of Briquettes.	Pounds per Square Inch.	Number of Briquettes.	Pounds per Square Inch.	Number of Briquettes.	Pounds per Square Inch.	Number of Briquettes.	Pounds per Square Inch.
Atlas,	18,509	Neat,	65	848	80	813	55	796	-	-
		2 to 1,	65	324	80	325	55	340	-	-
Brooks-Shoobridge,	5,706	Neat,	5	674	55	702	50	684	15	678
		2 to 1,	5	521	55	447	50	458	15	469
Giant,	15,394	Neat,	55	598	55	622	42	609	-	-
		2 to 1,	55	426	55	422	42	418	-	-
Iron Clad,	7,778	Neat,	34	769	34	800	14	745	-	-
		2 to 1,	34	396	34	394	14	419	-	-
Stettin-Girstow,	979	Neat,	8	665	51	714	42	709	2	629
		2 to 1,	8	370	53	340	42	332	2	278
West Kent,	3,394	Neat,	19	586	59	589	51	570	19	578
		2 to 1,	19	522	59	434	51	424	19	399
Total,	51,760	Neat,	186	721	334	707	254	680	36	620
		2 to 1,	186	395	336	389	254	396	36	421

Tabulation of Cement Tests of Cement used in the Construction of the Wachusett Dam during the Year 1901.

BRAND.	Number of Barrels used.	Composition of Briquette.	FINENESS.			WIRE TESTS.		TENSILE STRENGTH.							
								ONE DAY.		SEVEN DAYS.		TWENTY-EIGHT DAYS.		THREE MONTHS.	
			Per Cent. Residue on No. 50 Sieve, 2,500 Meshes to Square Inch.	Per Cent. Residue on No. 100 Sieve, 10,000 Meshes to Square Inch.	Per Cent. Residue on No. 180 Sieve, 32,400 Meshes to Square Inch.	Minutes to bear Light Wire.	Minutes to bear Heavy Wire.	Number of Briquettes.	Pounds per Square Inch.	Number of Briquettes.	Pounds per Square Inch.	Number of Briquettes.	Pounds per Square Inch.	Number of Briquettes.	Pounds per Square Inch.
Giant (Portland), ...	17,703	Neat, . .	.6	10.5	24.6	102	327	1,687	635	1,634	828	1,649	896	60	894
		2 to 1, . .	-	-	-	-	316	-	-	1,693	390	1,648	440	60	406
Union (natural), ...	8,892	Neat, . .	.9	5.8	13.5	33	74	964	183	962	234	933	308	25	379
		1 to 1, . .	-	-	-	26	56	-	-	958	203	933	298	25	452

Tabulation of Cement Tests for All Brands of Natural and Portland Cement used in Construction of the Weston Aqueduct during 1901.

BRAND.	Number of Barrels used.	Composition of Briquette.	FINENESS.			WIRE TESTS.		TENSILE STRENGTH.									
								ONE DAY.		SEVEN DAYS.		TWENTY-EIGHT DAYS.		THREE MONTHS.		SIX MONTHS.	
			Per Cent. Residue on No. 50 Sieve, 2,500 Meshes to Square Inch.	Per Cent. Residue on No. 100 Sieve, 10,000 Meshes to Square Inch.	Per Cent. Residue on No. 180 Sieve, 32,400 Meshes to Square Inch.	Minutes to bear Light Wire.	Minutes to bear Heavy Wire.	Number of Briquettes.	Pounds per Square Inch.	Number of Briquettes.	Pounds per Square Inch.	Number of Briquettes.	Pounds per Square Inch.	Number of Briquettes.	Pounds per Square Inch.	Number of Briquettes.	Pounds per Square Inch.
Natural cements: —																	
Hoffman, ...	20,400	Neat, .	2.6	12.3	-	25	60	1,564	166	1,566	188	437	267	115	363	-	-
		1 to 1, .	-	-	-	28	71	-	-	1,492	145	483	230	118	368	-	-
Union, ...	6,258	Neat, .	0.9	6.2	12.8	45	88	451	187	454	235	182	295	3	379	-	-
		1 to 1, .	-	-	-	37	88	-	-	446	207	195	284	5	415	-	-
Totals, ...	26,658	Neat, .	2.2	10.8	-	30	67	2,015	171	2,020	199	619	276	118	363	-	-
		1 to 1, .	-	-	-	30	76	-	-	1,988	160	628	247	118	370	-	-
Portland cements: —																	
Atlas, ...	11,430	Neat, .	0.2	8.4	18.6	74	263	890	572	900	757	397	795	57	859	4	949
		2 to 1, .	-	-	-	-	206	-	-	860	292	396	379	43	429	10	537
Giant, ...	2,380	Neat, .	0.2	9.6	20.4	64	290	172	496	177	685	83	754	5	975	-	-
		2 to 1, .	-	-	-	-	236	-	-	167	296	86	375	-	-	-	-
Totals, ...	13,810	Neat, .	0.2	8.6	18.9	72	268	1,062	559	1,077	745	480	788	62	868	4	949
		2 to 1, .	-	-	-	-	220	-	-	1,027	298	482	379	43	429	10	537

APPENDIX No. 3.

TABLE No. 1. — *Monthly Rainfall in Inches at Various Places on the Metropolitan Water Works, in 1901.*

PLACE.		January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.
Nashua watershed.	Princeton, ...	1.63	0.98	5.30	9.84	6.85	1.03	5.56	4.78	3.22	3.77	2.47	9.46	54.89
	Jefferson, ...	1.91	1.39	6.02	9.44	7.33	2.25	5.55	4.92	2.93	3.96	2.32	9.35	57.37
	Sterling, ...	1.52	0.96	5.79	10.03	6.86	1.65	5.51	3.99	2.90	3.34	2.07	8.84	53.46
	Boylston,*	1.93	1.20	6.18	9.25	7.05	1.13	6.03	4.62	3.34	3.72	2.84	9.80	57.09
Sudbury watershed.	Sudbury Dam, ...	1.81	1.35	6.34	8.19	7.74	1.37	5.08	4.10	2.91	3.04	2.70	8.29	52.92
	Framingham, ...	1.86	1.49	6.41	8.00	7.01	1.20	5.19	4.42	2.96	2.57	2.72	10.87	54.70
	Ashland Dam, ...	1.97	1.74	6.73	8.34	6.72	1.39	6.37	4.82	3.62	2.62	2.91	10.30	57.53
	Cordaville, ...	1.65	1.51	6.80	9.87	7.43	1.56	6.19	4.93	3.73	3.04	3.26	9.31	59.28
Lake Cochituate, ...		1.85	1.80	6.35	7.51	6.93	1.26	6.67	4.48	3.17	2.83	3.03	8.58	54.46
Chestnut Hill Reservoir, . .		1.72	0.77	7.25	8.21	7.14	1.23	6.40	4.15	3.25	3.01	2.83	8.25	54.21
Spot Pond, ...		1.78	0.82	6.83	8.36	7.19	1.86	4.69	3.64	3.67	2.54	2.78	7.96	52.07
Average of all, ...		1.78	1.27	6.36	8.82	7.12	1.45	5.75	4.44	3.25	3.13	2.72	9.18	55.27
Average, Nashua watershed, .		1.75	1.13	5.82	9.64	7.02	1.51	5.66	4.58	3.10	3.70	2.43	9.36	55.70
Average, Sudbury watershed,		1.82	1.52	6.57	8.60	7.23	1.38	5.71	4.57	3.30	2.82	2.90	9.69	56.11

* The rainfall station at Boylston has been substituted for that at South Clinton, of which the records have been given in former reports.

TABLE No. 2. — *Rainfall in Inches at Jefferson, Mass., in 1901.*

DAY OF MONTH.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1,	-	-	-	-	-	-	-	-	0.71†	-	0.11†	-
2,	-	-	0.06†	-	*	-	0.08†	-	-	0.75†	-	-
3,	-	-	-	*	0.40†	-	-	0.18†	-	-	-	*
4,	-	*	0.30†	*	-	0.07†	-	0.10†	-	-	-	2.90‖
5,	-	1.15‡	0.40‡	2.41§	-	-	0.07†	-	-	-	-	-
6,	-	-	-	*	-	-	*	*	-	0.14†	-	-
7,	-	-	-	*	-	0.35†	0.55†	1.75†	-	-	-	-
8,	-	-	-	*	-	-	-	-	-	-	-	-
9,	0.12†	-	0.20‡	*	-	-	0.23†	-	-	-	-	-
10,	*	-	*	2.66†	*	-	-	-	*	-	-	0.77†
11,	*	-	2.25†	-	1.00†	-	*	-	0.41†	-	*	-
12,	1.12‖	-	-	-	0.24†	-	0.75†	0.06†	0.22†	*	0.70‖	-
13,	-	-	*	-	-	-	-	-	-	*	-	-
14,	*	-	*	-	-	-	-	-	-	*	0.07‡	*
15,	*	-	*	-	-	-	-	-	0.35†	2.90†	-	1.75†
16,	*	*	0.25‡	0.14†	-	-	-	-	-	-	-	-
17,	0.08‡	0.09‡	-	-	-	-	0.90†	*	*	*	-	*
18,	-	-	-	-	*	-	-	0.30†	*	0.13§	-	0.11‡
19,	-	-	-	-	*	-	-	0.13†	0.80†	0.04§	0.10‡	-
20,	*	-	-	*	1.85†	-	-	*	-	-	-	-
21,	0.05†	-	1.35†	*	-	*	-	0.15†	-	-	-	-
22,	-	0.07‡	-	*	0.14†	1.03†	0.06†	-	-	-	-	-
23,	*	*	-	*	-	0.80†	-	-	-	-	-	*
24,	0.20¶	0.08‡	0.17†	*	*	-	-	*	-	-	*	0.65‖
25,	-	-	-	3.90†	1.60†	-	1.10†	2.25†	-	-	1.30§	0.05†
26,	-	-	*	-	-	-	-	-	-	-	0.04‡	*
27,	*	-	1.05†	-	*	-	-	-	-	-	-	0.87‡
28,	0.04‡	-	-	-	*	-	*	-	-	-	-	*
29,	-	-	-	-	*	-	1.81†	-	*	-	-	*
30,	*	-	-	0.33†	2.10†	-	-	-	0.44†	-	-	2.25†
31,	0.30‡	-	-	-	-	-	-	-	-	-	-	-
Totals,	1.91	1.39	6.02	9.44	7.33	2.25	5.55	4.92	2.93	3.96	2.32	9.35

Total for the year, 57.37 inches.

* Rainfall included in that of following day. † Rain. ‡ Snow.
§ Rain and snow. ‖ Rain, snow and hail. ¶ Snow and hail.

TABLE NO. 3. — *Rainfall in Inches at Framingham, Mass., in 1901.*

DAY OF MONTH.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1,	-	-	-	-	-	0.04†	-	-	0.24†	-	0.04†	-
2,	-	-	0.13†	0.02†	0.70†	-	0.26†	-	0.02†	*	-	*
3,	-	-	0.20†	*	-	-	-	0.03†	0.12†	0.51†	-	1.77§
4,	-	*	*	*	-	-	-	0.06†	-	-	-	-
5,	-	1.35‡	0.35§	1.93†	-	-	0.19†	-	-	0.09†	-	-
6,	-	-	-	*	-	-	0.21†	*	-	0.05†	-	-
7,	-	-	-	*	-	*	0.02†	1.34†	-	-	-	-
8,	0.02†	-	*	*	-	0.42†	-	-	-	-	-	-
9,	-	-	0.33†	*	-	-	0.21†	-	-	-	-	-
10,	0.50§	-	*	2.50†	*	-	-	-	*	-	-	1.09†
11,	*	-	2.26†	-	1.32†	-	1.29†	0.06†	0.69†	-	*	-
12,	0.75§	0.02‡	-	-	-	-	-	0.02†	0.11†	-	0.35§	*
13,	-	-	-	-	0.27†	-	-	0.02†	0.06†	0.02†	-	0.12†
14,	*	-	0.12¶	-	-	-	-	-	-	*	-	*
15,	*	-	0.01‡	*	-	-	-	0.03†	0.62†	1.85†	-	3.02†
16,	0.14§	0.01‡	-	0.55†	-	-	-	-	-	-	-	-
17,	0.10‡	-	-	-	-	-	0.42†	*	0.28†	0.05†	-	*
18,	-	-	-	-	*	-	-	0.44†	*	-	*	0.12‡
19,	-	-	-	-	*	-	-	0.06†	0.24†	-	0.21‡	0.02‡
20,	-	-	*	*	2.47†	-	-	-	0.06†	-	-	-
21,	0.01†	-	1.02†	*	-	0.05†	0.03†	-	-	-	-	-
22,	-	-	-	*	0.13†	0.63†	-	-	-	-	-	-
23,	*	*	-	*	-	0.04†	-	-	-	-	0.02‡	*
24,	0.12†	0.11‡	0.27†	*	*	0.02†	*	*	-	-	*	1.00†
25,	-	-	-	2.74†	0.74†	-	1.00†	2.36†	-	-	2.08†	0.02†
26,	-	-	*	-	*	-	0.02†	-	-	-	0.02‡	*
27,	-	-	1.72†	-	*	-	-	-	-	-	-	0.91§
28,	-	-	-	-	*	-	*	-	-	-	-	-
29,	-	-	-	-	*	-	1.54†	-	0.52†	-	-	*
30,	*	-	-	0.26†	1.37†	-	-	-	-	-	-	2.80†
31,	0.22‡	-	-	-	0.01†	-	-	-	-	-	-	-
Totals,	1.86	1.49	6.41	8.00	7.01	1.20	5.19	4.42	2.96	2.57	2.72	10.87

Total for the year, 54.70 inches.

* Rainfall included in that of following day. † Rain. ‡ Snow.

§ Rain and snow. ¶ Snow and hail.

TABLE No. 4. — *Rainfall at Chestnut Hill Reservoir in 1901.*

DATE.	Inches.	Rain or Snow.	Duration.	
Jan. 10,	0.53	Snow.	1.15 P.M. to	
Jan. 11,				1.30 A.M.
Jan. 11,	0.75	Rain and snow.	1.30 P.M. to	
Jan. 12,				3.15 P.M.
Jan. 15,	0.09	Snow and rain.	4.30 A.M. to	3.00 P.M.
Jan. 17,	0.10	Snow.	6.30 P.M. to	
Jan. 18,				2.00 A.M.
Jan. 30,	0.25	Snow.	3.15 P.M. to	
Jan. 31,				10.00 P.M.
Total,	1.72			
Feb. 4,	0.60	Snow.	6.00 A.M. to	
Feb. 5,				7.00 A.M.
Feb. 23,	0.17	Snow.	11.00 P.M. to	
Feb. 24,				9.30 A.M.
Total,	0.77			
Mar. 2,	0.17	Rain.	9.00 A.M. to	2.00 P.M.
Mar. 4,	0.23	Rain.	1.45 A.M. to	4.30 A.M.
Mar. 4,	0.28	Rain and snow.	9.00 P.M. to	
Mar. 5,				8.15 A.M.
Mar. 9,	0.44	Rain.	4.00 A.M. to	
Mar. 10,				8.30 P.M.
Mar. 10,	2.25	Rain.	11.30 P.M. to	
Mar. 11,				8.30 P.M.
Mar. 14,	0.13	Rain.	1.30 A.M. to	3.00 P.M.
Mar. 20,	0.14	Rain.	6.45 P.M. to	
Mar. 21,				4.00 A.M.
Mar. 21,	1.45	Rain.	10.00 A.M. to	10.30 P.M.
Mar. 24,	0.16	Rain.	2.00 P.M. to	10.00 P.M.
Mar. 26,	2.00	Rain.	8.00 A.M. to	
Mar. 27,				1.30 A.M.
Total,	7.25			
Apr. 3,	1.67	Rain.	7.45 A.M. to	9.30 P.M.
Apr. 4,	0.16	Rain.	9.00 A.M. to	10.00 P.M.
Apr. 6,	1.89	Rain.	8.00 P.M. to	
Apr. 7,				7.30 A.M.
Apr. 8,	0.03	Mist.	During day.	
Apr. 9,	0.15	Showers.	During day.	
Apr. 10,	0.07	Showers.	During day.	
Apr. 15,	0.78	Rain.	4.15 P.M. to	
Apr. 16,				7.30 P.M.
Apr. 20,	0.57	Rain.	1.30 P.M.	
Apr. 21,			to	
Apr. 22,				
Apr. 23,				7.00 A.M.
Apr. 23,	0.02	Rain.	7.00 A.M. to	
Apr. 24,				7.00 A.M.
Apr. 24,	2.59	Rain.	7.00 A.M	
Apr. 25,			to	
Apr. 26,				7.00 A.M.
Apr. 30,	0.28	Rain.	12.15 P.M. to	11.30. P.M.
Total,	8.21			
May 2,	0.92	Rain.	2.30 P.M. to	
May 3,				3.00 A.M.
May 10,	1.03	Rain.	12.10 A.M. to	
May 11,				2.00 A.M.
May 13,	0.27	Rain.	6.10 A.M. to	9.10 A.M.
May 18,	2.68	Rain.	1.00 P.M.	
May 19,			to	
May 20,				7.00 A.M.
May 23,	0.08	Rain.	12.30 A.M. to	2.00 A.M.
May 24,	0.83	Rain.	4.40 P.M. to	
May 25,				7.15 A.M.
May 27,	0.37	Rain.	12.30 A.M. to	7.00 A.M.
May 27,	0.86	Rain.	1.15 P.M.	
May 28,			to	
May 29,				7.00 A.M.
June 1,	0.10	Rain.	2.00 A.M. to	3.00 A.M.
Total,	7.14			
June 7,	0.50	Rain.	5.35 P.M. to	
June 8,				4.30 A.M.
June 21,	0.10	Rain.	7.00 A.M. to	12.20 P.M.

TABLE No. 4. — *Rainfall at Chestnut Hill Reservoir in 1901* — Concluded.

DATE.	Inches.	Rain or Snow.	Duration.
June 22,	0.53	Rain.	7.40 A.M. to 9.40 A.M.
June 22,	0.05	Rain.	10.10 A.M. to 11.30 A.M.
June 23,			1.00 A.M. to 1.35 A.M.
June 24,	0.03	Rain.	9.15 P.M. to 11.00 P.M.
June 30,	0.02	Rain.	1.05 A.M. to 1.25 A.M.
Total,	1.23		
July 5,	0.21	Rain.	12.30 A.M. to 2.00 A.M.
July 6,	0.06	Rain.	2.00 A.M. to 4.30 A.M.
July 6,	0.32	Rain.	9.00 A.M. to 9.50 A.M.
July 6,	0.02	Shower.	During evening.
July 9,	0.11	Rain.	8.10 A.M. to 1.30 P.M.
July 11,	2.15	Rain.	4.20 P.M. to
July 12,			1.00 A.M.
July 17,	0.45	Rain.	1.10 P.M. to 3.30 P.M.
July 22,	0.03	Rain.	12.45 A.M. to 1.15 A.M.
July 25,	0.95	Rain.	1.30 A.M. to 6.15 A.M.
July 29,	2.10	Rain.	12.30 A.M. to 6.00 A.M.
Total,	6.40		
Aug. 4,	0.13	Rain.	2.15 P.M. to 9.30 P.M.
Aug. 7,	1.45	Rain.	8.30 A.M. to 2.15 P.M.
Aug. 11,	0.10	Rain.	3.05 A.M. to 3.45 A.M.
Aug. 18,	0.34	Rain.	10.15 P.M. to
Aug. 19,			3.40 A.M.
Aug. 25,	2.10	Rain.	6.30 P.M. to
Aug. 26,			12.45 A.M.
Sept. 1,	0.03	Rain.	1.15 A.M. to 7.00 A.M.
Total,	4.15		
Sept. 1,	0.37	Rain.	7.00 A.M. to 4.00 P.M.
Sept. 11,	0.67	Rain.	8.30 A.M. to 11.40 A.M.
Sept. 11,	0.10	Rain.	5.50 P.M. to 7.30 P.M.
Sept. 12,	0.15	Rain.	2.00 P.M. to 8.30 P.M.
Sept. 15,	0.29	Rain.	8.30 P.M. to 9.45 P.M.
Sept. 17,	0.45	Rain.	11.10 A.M. to 5.10 P.M.
Sept. 18,	0.35	Rain.	10.00 A.M. to
Sept. 19,			7.00 A.M.
Sept. 20,	0.16	Rain.	4.30 P.M. to 8.30 P.M.
Sept. 29,	0.71	Rain.	2.00 A.M. to 11.30 P.M.
Total,	3.25		
Oct. 2,	0.48	Rain.	10.00 P.M. to
Oct. 3,			2.00 A.M.
Oct. 6,	0.12	Rain.	2.00 A.M. to 7.00 A.M.
Oct. 6,	0.01	Rain.	9.30 A.M. to 5.00 P.M.
Oct. 14,	2.36	Rain.	2.00 A.M. to 11.00 P.M.
Oct. 17,	0.04	Rain.	1.50 P.M. to 5.20 P.M.
Total,	3.01		
Nov. 11,	0.47	Snow and rain.	4.15 P.M.
Nov. 12,			to
Nov. 13,			1.30 A.M.
Nov. 19,	0.11	Snow.	1.30 A.M. to 7.15 P.M.
Nov. 24,	2.21	Rain.	8.45 A.M. to
Nov. 25,			5.30 P.M.
Nov. 26,	0.04	Snow.	4.30 A.M. to 9.30 A.M.
Total,	2.83		
Dec. 3,	1.53	Rain and snow.	3.30 A.M. to
Dec. 4,			2.00 A.M.
Dec. 9,	1.02	Rain.	10.00 P.M. to
Dec. 10,			9.20 A.M.
Dec. 10,	0.03	Rain.	10.00 A.M. to 10.45 A.M.
Dec. 13,	0.08	Rain.	6.15 P.M. to 7.30 P.M.
Dec. 14,	1.65	Rain.	9.30 P.M. to
Dec. 15,			5.30 P.M.
Dec. 17,	0.12	Snow.	10.00 A.M. to
Dec. 18,			9.30 A.M.
Dec. 24,	0.78	Rain.	2.00 A.M. to 10.30 A.M.
Dec. 26,	0.86	Snow and rain.	8.30 P.M. to
Dec. 27,			2.00 P.M.
Dec. 29,	2.18	Rain.	5.00 A.M. to
Dec. 30,			8.30 P.M.
Total,	8.25		

Total rainfall for the year, 54.21 inches.

TABLE No. 5. — *Rainfall, in Inches, on the Sudbury Watershed,* 1875 to 1901.*

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Totals.
1875,	2.42	3.15	3.74	3.23	3.56	6.24	3.57	5.53	3.43	4.85	4.83	0.94	45.49
1876,	1.83	4.21	7.43	4.20	2.76	2.04	9.13	1.72	4.62	2.24	5.76	3.62	49.56
1877,	3.22	0.74	8.36	3.43	3.70	2.43	2.95	3.68	0.32	8.52	5.80	0.87	44.02
1878,	5.63	5.97	4.69	5.79	0.96	3.88	2.97	6.94	1.29	6.42	7.02	6.37	57.93
1879,	2.48	3.56	5.14	4.72	1.58	3.79	3.93	6.51	1.88	0.81	2.68	4.34	41.42
1880,	3.57	3.98	3.31	3.11	1.84	2.14	6.27	4.01	1.60	3.74	1.78	2.83	38.18
1881,	5.56	4.65	5.73	2.00	3.51	5.39	2.35	1.36	2.62	2.96	4.06	3.98	44.17
1882,	5.95	4.55	2.65	1.82	5.07	1.66	1.77	1.67	8.74	2.07	1.15	2.30	39.40
1883,	2.81	3.87	1.78	1.84	4.19	2.40	2.68	0.73	1.52	5.60	1.81	3.55	32.78
1884,	5.09	6.54	4.72	4.41	3.47	3.44	3.67	4.65	0.85	2.48	2.65	5.17	47.14
1885,	4.71	3.87	1.07	3.60	3.48	2.87	1.43	7.18	1.43	5.02	6.09	2.79	43.54
1886,	6.36	6.28	3.61	2.22	3.00	1.47	3.27	4.10	2.90	3.24	4.64	4.97	46.06
1887,	5.20	4.78	4.90	4.27	1.16	2.65	3.76	5.28	1.82	2.83	2.67	3.38	42.70
1888,	4.15	3.68	6.02	2.43	4.82	2.54	1.41	6.22	8.59	4.89	7.32	5.40	57.47
1889,	5.37	1.65	2.37	3.41	2.95	2.80	8.94	4.18	4.60	4.25	6.29	3.14	49.95
1890,	2.53	3.51	7.73	2.64	5.21	2.03	2.46	3.87	6.00	10.51	1.90	5.81	53.00
1891,	7.02	5.23	6.48	3.91	2.01	3.77	3.89	4.73	2.38	3.83	3.09	3.08	49.42
1892,	5.85	3.14	4.06	0.83	5.58	2.76	4.23	4.44	2.84	1.17	5.80	1.13	41.83
1893,	2.92	8.20	3.67	3.60	6.61	2.38	2.57	5.41	1.74	4.07	2.20	4.86	48.23
1894,	4.09	3.91	1.43	3.42	4.24	1.15	3.26	2.03	2.63	5.34	3.43	4.81	39.74
1895,	4.06	1.39	2.98	5.25	2.02	2.77	5.04	4.15	2.80	10.62	6.63	3.35	50.02
1896,	2.39	7.18	5.24	1.57	2.57	3.22	2.51	2.40	7.72	3.76	3.02	2.12	43.70
1897,	4.00	2.91	3.66	2.82	4.37	4.46	5.44	3.51	2.94	0.47	6.40	5.21	46.19
1898,	6.83	4.49	2.40	4.66	3.22	2.48	4.09	8.17	2.62	6.71	6.93	3.28	55.88
1899,	4.18	4.91	7.01	1.90	1.45	2.51	3.22	1.48	3.95	2.64	2.18	1.78	37.21
1900,	4.96	9.14	6.35	2.58	4.32	2.99	2.42	2.26	3.36	3.83	5.70	2.74	50.65
1901,	1.82	1.52	6.57	8.60	7.23	1.38	5.71	4.57	3.30	2.82	2.90	9.69	56.11
Totals,	115.00	117.01	123.10	92.26	94.88	77.64	102.44	110.78	87.40	115.96	113.96	102.06	1,252.49
Averages,	4.26	4.33	4.56	3.42	3.51	2.88	3.79	4.10	3.24	4.30	4.22	3.78	46.39

* Means of observations at several places, as follows: January, 1875, to April, 1876, Lake Cochituate; April to June, 1876, Lake Cochituate, Westborough and Hopkinton; June to December, 1876, Lake Cochituate, Southborough, Marlborough, Westborough and Hopkinton; December, 1876, to January, 1883, Framingham, Southborough, Marlborough, Westborough and Hopkinton; January, 1883, to January, 1884, Framingham and Southborough; January, 1884, to January, 1890, Framingham and Westborough; January, 1890, to May, 1898, Framingham and Ashland Dam; June, 1898, to December, 1901, Framingham, Ashland Dam, Cordaville and Sudbury Dam.

TABLE No. 6.—*Yield of the Sudbury Watershed in Gallons per Day per Square Mile* from 1875 to 1901.*

MONTHS.	1875.	1876.	1877.	1878.	1879.	1880.	1881.	1882.	1883.	1884.	1885.	1886.	1887.	1888.
January,	103,000	643,000	658,000	1,810,000	700,000	1,120,000	415,000	1,241,000	335,000	995,000	1,235,000	1,461,000	2,589,000	1,053,000
February,	1,496,000	1,368,000	949,000	2,465,000	1,711,000	1,787,000	1,546,000	2,403,000	1,033,000	2,842,000	1,354,000	4,801,000	2,829,000	1,950,000
March,	1,604,000	4,435,000	4,814,000	3,507,000	2,330,000	1,374,000	4,004,000	2,839,000	1,611,000	3,785,000	1,572,000	2,059,000	2,868,000	3,238,000
April,	3,049,000	3,292,000	2,394,000	1,626,000	3,116,000	1,169,000	1,546,000	867,000	1,350,000	2,853,000	1,815,000	1,947,000	2,620,000	2,645,000
May,	1,188,000	1,138,000	1,391,000	1,394,000	1,114,000	514,000	965,000	1,292,000	937,000	1,030,000	1,336,000	720,000	1,009,000	1,632,000
June,	870,000	222,000	597,000	506,000	413,000	175,000	1,338,000	529,000	300,000	416,000	426,000	203,000	413,000	421,000
July,	321,000	183,000	202,000	128,000	157,000	176,000	276,000	86,000	115,000	224,000	62,000	116,000	115,000	117,000
August,	396,000	405,000	121,000	476,000	395,000	119,000	148,000	55,000	79,000	257,000	240,000	94,000	214,000	379,000
September,	207,000	184,000	60,000	161,000	141,000	80,000	197,000	307,000	91,000	44,000	121,000	117,000	111,000	1,155,000
October,	646,000	234,000	631,000	516,000	71,000	102,000	186,000	299,000	186,000	83,000	336,000	146,000	190,000	1,999,000
November,	1,302,000	1,088,000	1,418,000	1,693,000	206,000	205,000	395,000	209,000	205,000	175,000	1,177,000	673,000	369,000	2,758,000
December,	584,000	453,000	1,290,000	3,177,000	463,000	175,000	775,000	315,000	194,000	925,000	1,174,000	1,020,000	643,000	3,043,000
Average for year,	972,000	1,135,000	1,214,000	1,452,000	894,000	578,000	979,000	862,000	533,000	1,129,000	901,000	1,087,000	1,154,000	1,697,000
Average for driest 6 months,	574,000	384,000	502,000	532,000	230,000	143,000	330,000	211,000	145,000	200,000	391,000	223,000	234,000	953,000

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* The area of the Sudbury watershed used in making up these records included water surfaces amounting to 1.9 per cent. of the whole area from 1875 to 1878 inclusive, and subsequently increased by the construction of storage reservoirs to 3.0 per cent. in 1879, 3.4 per cent. in 1885, 3.9 per cent. in 1894 and 6.5 per cent. in 1898. The watershed also contains extensive areas of swampy land, which, though covered with water at times, are not included in the above percentages of water surfaces.

TABLE No. 6. — *Yield of the Sudbury Watershed in Gallons per Day per Square Mile * from 1875 to 1901* — Concluded.

MONTHS.	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	Mean for 27 years. 1875-1901.
January,	2,782,000	1,254,000	3,018,000	1,870,000	434,000	693,000	1,034,000	1,084,000	845,000	1,638,000	2,288,000	794,000	437,000	1,205,000
February,	1,196,000	1,529,000	3,486,000	943,000	1,542,000	991,000	541,000	2,676,000	1,067,000	3,022,000	1,381,000	3,800,000	300,000	1,889,000
March,	1,338,000	3,643,000	4,453,000	1,955,000	3,245,000	2,238,000	2,410,000	3,835,000	2,565,000	2,604,000	4,205,000	3,654,000	2,755,000	2,923,000
April,	1,410,000	1,875,000	2,397,000	871,000	2,125,000	1,640,000	2,515,000	1,494,000	1,515,000	1,829,000	2,521,000	1,350,000	4,204,000	2,075,000
May,	880,000	1,366,000	583,000	1,259,000	2,883,000	840,000	636,000	360,000	915,000	1,246,000	511,000	1,312,000	2,954,000	1,163,000
June,	653,000	568,000	413,000	428,000	440,000	419,000	174,000	399,000	962,000	530,000	66,000	316,000	753,000	480,000
July,	634,000	107,000	149,000	214,000	158,000	161,000	231,000	95,000	658,000	231,000	19,000	—18,000	306,000	194,000
August,	1,432,000	132,000	163,000	280,000	181,000	209,000	229,000	57,000	591,000	1,107,000	—35,000	—34,000	424,000	301,000
September,	823,000	457,000	203,000	229,000	108,000	150,000	89,000	388,000	182,000	369,000	94,000	65,000	305,000	238,000
October,	1,230,000	2,272,000	210,000	126,000	222,000	374,000	1,379,000	592,000	94,000	1,160,000	115,000	186,000	412,000	518,000
November,	1,941,000	1,215,000	305,000	697,000	319,000	836,000	2,777,000	659,000	909,000	1,986,000	304,000	663,000	474,000	924,000
December,	2,241,000	996,000	544,000	485,000	796,000	716,000	1,782,000	657,000	1,584,000	1,799,000	220,000	1,096,000	2,695,000	1,105,000
Average for year,	1,383,000	1,285,000	1,315,000	781,000	1,037,000	770,000	1,152,000	1,019,000	991,000	1,450,000	973,000	1,082,000	1,342,000	1,081,000
Average for driest 6 months,	944,000	747,000	239,000	327,000	237,000	356,000	460,000	314,000	564,000	777,000	93,000	194,000	445,000	441,000

*** The area of the Sudbury watershed used in making up these records included water surfaces amounting to 1.9 per cent. of the whole area from 1875 to 1878 inclusive, and subsequently increased by the construction of storage reservoirs to 3.0 per cent. in 1879, 3.4 per cent. in 1885, 3.9 per cent. in 1894 and 6.5 per cent. in 1898. The watershed also contains extensive areas of swampy land, which, though covered with water at times, are not included in the above percentages of water surfaces.**

TABLE NO. 7. — *Sudbury River. — Statistics of Flow of Water, Storage and Rainfall in 1901.*

[Watershed from 1875 to 1878 inclusive = 77.764 square miles; in 1879 and 1880 = 78.238 square miles; and from 1881 to 1901 inclusive = 75.2 square miles.]

MONTHS.	Quantity of Water received through Wachusett Aqueduct (Gallons per Day).	Quantity of Water discharged through Sudbury Aqueduct (Gallons per Day).	Quantity of Water used by Framingham Water Company (Gallons per Day).	Quantity of Water diverted from Watershed by Sewers, etc. (Gallons per Day).	Quantity of Water wasted into River below Lowest Dam (Gallons per Day).	STORAGE.		Total Flow of River (Gallons per Day).	Rainfall (Inches).	Rainfall collected (Inches).	Percentage of Rainfall collected.
						Gain (Gallons per Day).	Loss (Gallons per Day).				
January, . . .	75,168,000	102,574,000	397,000	503,000	15,419,000	-	10,890,000	32,835,000	1.82	0.779	42.7
February, . . .	45,657,000	100,807,000	404,000	471,000	8,186,000	-	41,672,000	22,539,000	1.52	0.483	31.7
March, . . .	124,065,000	101,313,000	378,000	1,390,000	43,419,000	184,720,000	-	207,155,000	6.57	4.912	74.8
April, ...	39,277,000	82,743,000	390,000	2,607,000	228,427,000	41,230,000	-	316,120,000	8.60	7.257	84.4
May, ...	58,336,000	86,439,000	423,000	2,200,000	188,548,000	2,845,000	-	222,119,000	7.23	5.269	72.9
June, ...	75,120,000	99,143,000	517,000	973,000	38,407,000	-	7,313,000	56,607,000	1.38	1.299	94.1
July, ...	57,339,000	83,249,000	500,000	281,000	3,419,000	-	7 113,000	22,997,000	5.71	0.545	9.6
August, . . .	59,687,000	76,632,000	458,000	419,000	23,497,000	-	9,471,000	31,848,000	4.57	0.756	16.5
September, . .	41,627,000	71,447,000	480,000	437,000	20,420,000	-	28,190,000	22,967,000	3.30	0.527	16.0
October, . . .	48,674,000	82,048,000	478,000	390,000	22,148,000	-	25,445,000	30,945,000	2.82	0.734	26.1
November, . . .	54,850,000	93,970,000	463,000	363,000	37,940,000	-	42,228,000	35,663,000	2.90	0.819	28.3
December, . . .	87,890,000	104,129,000	474,000	1,381,000	120,193,000	64,381,000	-	202,668,000	9.69	4.808	49.6
Totals, . .	-	-	-	-	-	-	-	-	56.11	28.188	-
Average for year,	64,248,000	90,328,000	447,000	954,000	62,742,000	10,707,000	-	100,930,000	-	-	50.2

TABLE No. 8. — *Lake Cochituate. — Statistics of Flow of Water, Storage and Rainfall in 1901.*

[Watershed of lake = 18.87 square miles.*]

MONTHS.	Quantity of Water received through Sudbury Aqueduct (Gallons per Day).	Quantity of Water discharged through Cochituate Aqueduct (Gallons per Day).	Quantity of Water diverted from Snake Brook† (Gallons per Day).	Quantity of Water diverted from Watershed by Sewers, etc. (Gallons per Day).	Quantity of Water wasted at Outlet (Gallons per Day).	STORAGE. Gain (Gallons per Day).	STORAGE. Loss (Gallons per Day)	Quantity of Water collected in Lake (Gallons per Day).	Rainfall (Inches).	Rainfall collected (Inches).	Percentage of Rainfall collected.
January, . . .	7,535,000	14,739,000	-	526,000	-	2,509,000	-	10,239,000	1.85	0.968	52.3
February, . .	-	14,564,000	-	397,000	-	-	7,293,000	7,068,000	1.80	0.655	36.4
March, . . .	5,839,000	16,536,000	-	906,000	-	34,794,000	-	46,897,000	6.35	4.434	69.8
April, . . .	4,817,000	15,633,000	-	1,933,000	20,344,000	23,600,000	-	56,693,000	7.51	5.187	69.1
May, . . .	-	3,825,000	-	1,710,000	39,055,000	584,000	-	45,174,000	6.93	4.269	61.6
June, . . .	-	6,660,000	-	870,000	6,363,000	-	1,466,000	12,427,000	1.26	1.137	90.2
July, . . .	-	19,442,000	-	429,000	-	-	10,210,000	9,661,000	6.67	0.918	13.7
August, . . .	-	23,800,000	-	436,000	-	-	10,810,000	13,426,000	4.48	1.269	28.3
September, . .	-	23,693,000	1,923,000	420,000	-	-	13,698,000	12,843,000	3.17	1.129	35.6
October, . .	-	21,500,000	2,003,000	391,000	-	-	10,684,000	13,210,000	2.83	1.249	44.1
November, . .	-	10,670,000	1,603,000	340,000	-	-	-	12,618,000	3.03	1.154	38.1
December, . .	-	7,490,000	5,694,000	1,029,000	4,889,000	25,771,000	-	44,828,000	8.58	4.237	49.4
Totals, . . .	-	-	-	-	-	-	-	-	54.46	26.601	-
Average for year,	1,489,000	14,890,000	944,000	784,000	5,928,000	2,847,000	-	23,899,000	-	-	48.8

* Not including the watershed of Dudley Pond.

† On account of work in progress at Snake Brook Meadow.

TABLE No. 9. — *Nashua River. — Statistics of Flow of Water, Storage and Rainfall, July, 1896, to December, 1901, inclusive.**

[Watershed = 119.00 square miles.]

MONTHS.	Quantity of Water discharged through Wachusett Aqueduct (Million Gallons per Day).†	Quantity of Water wasted into River (Million Gallons per Day).	STORAGE.‡		Total Flow of River (Million Gallons per Day).	Rainfall (Inches).	Rainfall collected (Inches).	Percentage of Rainfall collected.
			Gain (Million Gallons per Day).	Loss (Million Gallons per Day).				
1896.								
July,	-	39.941	-	-	39.941	4.74	0.599	12.6
August,	-	35.959	-	-	35.959	2.62	0.539	20.6
September,	-	54.340	-	-	54.340	7.31	0.788	10.8
October,	-	94.451	-	-	94.451	3.72	1.415	38.1
November,	-	108.442	-	-	108.442	2.99	1.572	52.6
December,	-	111.265	-	-	111.265	2.22	1.668	74.9
Totals,	-	-	-	-	-	23.60	6.581	-
Average, 6 months,	-	73.987	-	-	73.987	-	-	27.9
1897.								
January,	-	94.736	-	-	94.736	3.46	1.420	41.0
February,	-	110.742	-	-	110.742	2.86	1.500	52.5
March,	-	328.480	-	-	328.480	4.01	4.922	122.9
April,	-	194.189	-	-	194.189	2.32	2.818	121.5
May,	-	144.442	-	6.000	138.442	5.06	2.075	41.0
June,	-	143.657	-	3.100	140.557	5.11	2.039	39.9
July,	-	169.008	2.613	-	171.621	8.65	2.572	29.7
August,	-	116.027	-	9.387	106.640	3.47	1.599	46.1
September,	-	57.404	-	12.200	45.204	1.93	0.656	33.9
October,	-	38.964	-	10.000	28.964	0.94	0.434	46.2
November,	-	125.030	27.600	-	152.630	7.62	2.214	29.0
December,	-	261.362	9.419	-	270.781	6.41	4.059	63.3
Totals,	-	-	-	-	-	51.84	26.308	-
Average for year,	-	149.186	-	0.123	149.063	-	-	50.7
1898.								
January,	-	184.640	1.323	-	185.963	6.65	2.787	41.9
February,	-	194.609	-	-	194.609	3.30	2.635	79.8
March,	87.148	280.381	-	-	367.529	2.27	5.509	242.7
April,	99.210	142.046	-	-	241.256	4.43	3.500	79.0
May,	53.423	119.545	-	7.548	165.420	3.38	2.480	73.4
June,	47.437	62.926	-	11.843	98.520	3.11	1.429	46.0
July,	24.629	21.132	-	6.193	39.568	3.01	0.593	19.7
August,	0.006	149.807	7.806	-	157.619	10.61	2.363	22.3
September,	53.880	30.436	-	3.933	80.383	3.15	1.166	37.0
October,	14.844	154.456	10.226	-	179.526	7.21	2.691	37.3
November,	12.927	243.703	1.638	-	258.268	6.81	3.746	55.0
December,	89.803	154.607	0.839	-	245.249	3.99	3.676	92.2
Totals,	-	-	-	-	-	57.92	32.575	-
Average for year,	40.464	144.723	-	0.615	184.572	-	-	56.2

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* The gagings of the Nashua River (South Branch) at Clinton are here published for the first time. Attention is called to a description of the method of gaging, given on page 94.

† Including small quantities wasted in cleaning aqueduct.

‡ In ponds and mill reservoirs.

TABLE No. 9. — *Nashua River. — Statistics of Flow of Water, Storage and Rainfall, July, 1896, to December, 1901, inclusive* — Concluded.

[Watershed = 119.00 square miles.]

MONTHS.	Quantity of Water discharged through Wachusett Aqueduct (Million Gallons per Day).*	Quantity of Water wasted into River (Million Gallons per Day).	STORAGE.†		Total Flow of River (Million Gallons per Day).	Rainfall (Inches).	Rainfall collected (Inches).	Percentage of Rainfall collected.
			Gain (Million Gallons per Day).	Loss (Million Gallons per Day).				
1899.								
January,	117.136	131.500	0.290	-	248.926	2.93	3.731	127.2
February,	98.193	31.561	-	-	129.754	5.12	1.757	34.3
March,	104.500	226.106	-	0.258	330.348	6.75	4.952	73.4
April,	86.643	316.297	-	1.133	401.807	1.94	5.829	300.8
May,	80.819	28.045	-	6.290	102.574	1.33	1.538	115.6
June,	63.233	3.764	-	0.200	66.797	5.51	0.969	17.6
July,	44.807	3.145	-	5.839	42.113	3.82	0.631	16.5
August,	28.952	3.219	-	4.097	28.074	3.20	0.421	13.2
September,	29.507	2.663	-	2.433	29.737	4.11	0.431	10.5
October,	24.848	2.652	1.677	-	29.177	2.72	0.437	16.1
November,	42.920	2.780	5.467	-	51.167	1.94	0.742	38.3
December,	37.345	2.449	2.903	-	42.697	2.03	0.640	31.5
Totals,	-	-	-	-	-	41.40	22.078	-
Average for year,	63.039	62.903	-	0.847	125.095	-	-	53.3
1900.								
January,	63.894	11.980	18.903	-	94.777	4.56	1.420	31.1
February,	81.635	390.025	10.822	-	482.482	8.69	6.532	75.2
March,	100.100	342.858	-	-	442.958	6.19	6.639	107.3
April,	83.237	104.756	-	-	187.993	2.76	2.727	98.8
May,	61.803	109.000	-	6.322	164.481	4.34	2.467	56.8
June,	64.003	15.047	-	10.300	68.750	3.59	0.998	27.8
July,	35.042	3.213	-	12.387	25.868	3.20	0.388	12.1
August,	27.297	3.268	-	7.162	23.403	3.18	0.351	11.0
September,	15.637	3.166	-	3.633	15.170	3.46	0.220	6.4
October,	27.981	3.687	1.935	-	33.603	2.90	0.504	17.4
November,	59.230	26.643	18.267	-	104.140	6.44	1.510	23.4
December,	107.081	71.093	8.678	-	186.852	3.15	2.800	88.9
Totals,	-	-	-	-	-	52.46	26.556	-
Average for year,	60.461	88.512	1.496	-	150.469	-	-	50.6
1901.								
January,	75.168	4.448	-	17.871	61.745	1.75	0.926	52.9
February,	45.657	4.222	-	7.500	42.379	1.13	0.574	50.8
March,	124.065	165.164	34.258	-	323.487	5.82	4.849	83.3
April,	39.894	551.773	1.500	-	593.167	9.64	8.605	89.3
May,	58.336	267.939	-	1.523	324.752	7.02	4.867	69.3
June,	75.120	50.470	-	8.333	117.257	1.51	1.701	112.3
July,	57.339	7.235	-	7.839	56.735	5.66	0.851	15.0
August,	59.687	6.413	-	5.194	60.906	4.58	0.913	19.9
September,	41.627	4.943	-	8.500	38.070	3.10	0.552	17.8
October,	48.674	20.203	8.129	-	77.006	3.70	1.154	31.2
November,	54.850	5.136	1.467	-	61.453	2.43	0.892	36.7
December,	87.890	275.171	21.710	-	384.771	9.36	5.766	61.6
Totals,	-	-	-	-	-	55.70	31.650	-
Average for year,	64.299	114.058	0.972	-	179.329	-	-	56.8

* Including small quantities wasted in cleaning aqueduct.

† In ponds and mill reservoirs.

TABLE NO. 10. — *Yield of the Nashua River (South Branch) in Gallons per Day per Square Mile* from 1897 to 1901.*

MONTHS.	1897.	1898.	1899.	1900.	1901.	Mean for 5 Years, 1897-1901.
January,	796,000	1,563,000	2,092,000	796,000	519,000	1,153,000
February,	931,000	1,635,000	1,090,000	4,054,000	356,000	1,615,000
March,	2,760,000	3,088,000	2,776,000	3,722,000	2,718,000	3,014,000
April,	1,632,000	2,027,000	3,376,000	1,580,000	4,986,000	2,720,000
May,	1,163,000	1,390,000	862,000	1,382,000	2,729,000	1,506,000
June,	1,181,000	828,000	561,000	578,000	985,000	827,000
July,	1,442,000	333,000	354,000	217,000	477,000	565,000
August,	896,000	1,325,000	236,000	197,000	512,000	633,000
September,	380,000	676,000	250,000	127,000	320,000	351,000
October,	243,000	1,509,000	245,000	282,000	647,000	585,000
November,	1,283,000	2,170,000	430,000	875,000	517,000	1,055,000
December,	2,275,000	2,061,000	359,000	1,570,000	3,234,000	1,900,000
Average for year,	1,253,000	1,551,000	1,051,000	1,264,000	1,507,000	1,325,000
Average for driest 6 months,	886,000	1,013,000	312,000	377,000	576,000	668,000

* The area of the watershed used in making up these records includes water surfaces amounting to 2.2 per cent. of the whole area.

TABLE No. 11. — *Elevations of Water Surfaces of Reservoirs above Boston City Base at the Beginning of each Month.*

DATES.	Chestnut Hill Reservoir.	Lake Cochituate.	Dudley Pond.	Farm Pond.	Spot Pond.	FRAMINGHAM RESERVOIR.			Ashland Reservoir.	Sudbury Reservoir.	Hopkinton Reservoir.	Whitehall Reservoir.
						No. 1.	No. 2.	No. 3.				
	Ordinary High Water =134.00.	High Water =144 36.	High Water =156.46.	High Water =159.25.	High Water =163 00.	Flash Boards 169.27.	Flash Boards 177.12.	Flash Boards 186.50.	Flash Boards 225.23.	Flash Boards 259.97.	Flash Boards 305.00.	High Water =337.91.
Jan. 1, 1901, .	133.93	136.38	152.82	158.85	159.47	167.76	176.01	183.53	214.44	252.54	291.90	334.82
Feb. 1, 1901, .	133.87	136.83	152.44	158.83	159.49	167.68	175.94	183.58	216.23	251.01	293.32	335.20
March 1, 1901, .	132.25	135.62	152.39	158.74	159.52	167.53	171.95	183.45	217.10	247.23	294.08	335.40
April 1, 1901, .	133.97	141.25	153.15	159.39	161.90	167.99	176.80	183.78	225.22	258.62	304.74	337.29
May 1, 1901, .	134.21	144.28	154.21	160.05	163.22	168.33	176.92	186.74	224.67	260.02	305.00	339.16
June 1, 1901, .	133.76	144.35	155.03	159.87	162.96	168.25	176.94	186.88	225.09	260.16	305.18	339.14
July 1, 1901, .	134.54	144.18	154.84	159.57	163.17	169.17	177.86	184.64	225.31	259.98	305.26	338.91
Aug. 1, 1901, .	132.50	142.89	154.64	159.39	163.30	169.42	177.94	184.85	225.39	259.40	305.38	339.05
Sept. 1, 1901, .	131.97	141.39	154.86	159.30	163.09	169.46	177.22	184.25	225.34	258.83	305.27	339.03
Oct. 1, 1901, .	132.02 132.03	139.44	153.94	159.08	161.60	169.41	177.18	184.28	225.31	256.86	305.10	338.97
Nov. 1, 1901, .	131.91 131.93	137.78	153.61	158.89	162.83	169.42	177.19	184.11	225.31	254.90	305.04	339.06
Dec. 1, 1901, .	133.41 133.45	137.73	153.51	158.92	162.95	167.82	176.08	184.20	224.36	252.75	304.04	338.04
Jan. 1, 1902, .	133.89 133.93	141.65	154.29	159.48	163.78	168.89	176.53	183.86	224.90	257.85	304.89	338.30

NOTE. — Where two elevations are given for Chestnut Hill Reservoir, the first refers to Bradlee Basin and the second to Lawrence Basin.

TABLE No. 12. — *Times when the Sudbury and Cochituate Aqueducts have been in Service, and the Sources from which the Supply for the Sudbury Aqueduct has been drawn.*

Sudbury Aqueduct: —

From 7.00 A.M. Jan. 1 to 9.45 A.M. Feb. 18, from Framingham Reservoir No. 3.
From 9.45 A.M. Feb. 18 to 2.20 P.M. Mar. 8, from Framingham Reservoirs Nos. 2 and 3.
From 2.20 P.M. Mar. 8 to 11.00 A.M. Mar. 12, from Framingham Reservoirs Nos. 1, 2 and 3.
From 11.00 A.M. Mar. 12 to 11.30 A.M. Mar. 14, from Framingham Reservoirs Nos. 1 and 3.
From 11.30 A.M. Mar. 14 to 11.35 A.M. Mar. 23, from Framingham Reservoirs Nos. 1, 2 and 3.
From 11.35 A.M. Mar. 23 to 12.00 P.M. Apr. 11, from Framingham Reservoir No. 3.
From 6.00 P.M. Apr. 12 to 10.30 P.M. Apr. 17, from Framingham Reservoir No. 3.
From 4.30 P.M. Apr. 18 to 8.30 P.M. Apr. 24, from Framingham Reservoir No. 3.
From 3.00 P.M. Apr. 25 to 8.30 P.M. May 1, from Framingham Reservoir No. 3.
From 3.00 P.M. May 2 to 11.00 A.M. June 13, from Framingham Reservoir No. 3.
From 11.00 A.M. June 13 to 9.30 A.M. July 9, from Framingham Reservoirs Nos. 2 and 3.
From 9.30 A.M. July 9 to 7.00 A.M. July 26, from Framingham Reservoirs Nos. 1, 2 and 3.
From 7.00 A.M. July 26 to 10.40 A.M. Aug. 3, from Framingham Reservoirs Nos. 2 and 3.
From 10.40 A.M. Aug. 3 to 7.00 A.M. Jan. 1, 1902, from Framingham Reservoir No. 3.

Cochituate Aqueduct: —

From 7.00 A.M. Jan. 1 to 3.00 P.M. May 7.
From 5.15 P.M. June 11 to 7.00 A.M. Nov. 18.
From 12.00 M. Dec. 3 to 7.00 P.M. Dec. 6.
From 1.00 P.M. Dec. 9 to 12.00 M. Dec. 13.
From 3.00 P.M. Dec. 16 to 11.00 A.M. Dec. 21.
From 10.00 A.M. Dec. 22 to 10.00 A.M. Dec. 26.
From 1.00 P.M. Dec. 26 to 9.00 A.M. Dec. 30.
From 10.00 A.M. Dec. 31 to 7.00 A.M. Jan. 1, 1902.

TABLE No. 13. — *Average Daily Quantity of Water flowing through Aqueducts in 1901, by Months.*

MONTHS.	Wachusett Aqueduct (Gallons).	SUDBURY AQUEDUCT.			Cochituate Aqueduct (Gallons).
		From Framingham Reservoir No. 3 (Gallons).	From Framingham Reservoirs Nos. 1 and 2 (Gallons).	Total (Gallons).	
January, . .	75,168,000	102,574,000	-	102,574,000	14,739,000
February, . .	45,657,000	92,378,000	8,429,000	100,807,000	14,564,000
March, . . .	124,065,000	66,542,000	34,771,000	101,313,000	16,536,000
April, . . .	39,894,000	82,637,000	106,000	82,743,000	15,633,000
May, . . .	58,336,000	86,342,000	97,000	86,439,000	3,825,000
June, . . .	75,120,000	91,866,000	7,277,000	99,143,000	6,660,000
July, . . .	57,339,000	69,673,000	13,576,000	83,249,000	19,442,000
August, . . .	59,687,000	76,284,000	348,000	76,632,000	23,800,000
September, . .	41,627,000	71,447,000	-	71,447,000	23,693,000
October, . .	48,674,000	82,048,000	-	82,048,000	21,500,000
November, . .	54,850,000	93,970,000	-	93,970,000	10,670,000
December, . .	87,890,000	104,129,000	-	104,129,000	7,490,000
Averages, .	64,299,000	84,930,000	5,398,000	90,328,000	14,890,000

NOTE. — Slight discrepancies between the figures for flow in the Wachusett Aqueduct in this table and those in Table No. 7 are due to taking account of quantities wasted in cleaning the aqueduct which were not discharged into Sudbury Reservoir.

The Wachusett Aqueduct discharges into Sudbury Reservoir, whence the water flows into Framingham Reservoir No. 3. Of the total quantity flowing through the Sudbury Aqueduct, an average of 1,489,000 gallons per day flowed into Lake Cochituate, leaving an average of 88,839,000 gallons per day, which, with the exception of a small quantity wasted in cleaning the aqueduct, was discharged into Chestnut Hill Reservoir.

TABLE No. 14. — *Statement of Operations of Engines Nos. 1 and 2 at Chestnut Hill High-service Pumping Station for the Year 1901.*

[These engines were designed for the high service, but were used for low service, except as noted.]

MONTHS.	ENGINE No. 1.			ENGINE No. 2.			Total Amount pumped (Million Gallons).	Amount of Coal consumed (Pounds).	Coal consumed by Reserve Boiler, which also furnished Steam for Electric Lighting Plant (Pounds).	Amount of Ashes and Clinkers (Pounds).	Per Cent. of Ashes and Clinkers.	Quantity pumped per Pound of Coal, no Deduction for Heating or Lighting (Gallons).	Average Lift (Feet).	Duty in Foot-pounds per 100 Pounds of Coal, no Deduction for Heating or Lighting, 4.23 Per Cent. allowed for Slip.	Duty in Foot-pounds per 100 Pounds of Coal, on Basis of Plunger Displacement, no Deduction for Heating or Lighting.
	Total Pumping Time.		Amount pumped, 4.23 Per Cent. allowed for Slip (Million Gallons).	Total Pumping Time.		Amount pumped, 4.23 Per Cent. allowed for Slip (Million Gallons).									
	Hrs.	Min.		Hrs.	Min										
January,	-		-	-		-	-	-	-	-	-	-	-	-	-
February,	-		-	-		-	-	-	-	-	-	-	-	-	-
March (high service),	29	40	11.65	-		-	11.65	26,227	-	1,595	6.0	444.20	125.28	46,360,000	48,400,000
April,	25	35	10.63	-		-	10.63	22,087	26,057	2,509	11.4	481.28	45.86	18,390,000	19,200,000
May,	28	05	11.83	-		-	11.83	17,827	63,410	998	11.6	663.60	52.55	29,050,000	30,330,000
June,	153	00	62.05	2	20	0.94	62.99	53,787	23,123	4,153	7.7	1,171.10	52.28	51,000,000	53,250,000
July (high service),	166	20	71.72	-		-	71.72	107,207	23,855	9,732	9.1	668.99	126.40	70,440,000	73,550,000
August (high service),	41	05	17.35	-		-	17.35	20,181	39,889	1,920	9.5	859.72	124.56	89,200,000	93,130,000
September (high service),	4	10	1.77	7	45	2.54	4.31	10,029	27,378	1,020	10.2	429.75	124.24	44,480,000	46,440,000
September,	54	35	23.69	1	10	0.46	24.15	21,527	-	1,775	8.2	1,121.85	46.06	43,040,000	49,940,000
October,	224	50	94.91	-		-	94.91	74,628	7,623	6,718	9.0	1,271.77	45.60	48,310,000	50,440,000
November (high service),	22	45	8.87	-		-	8.87	17,940	50,125	1,590	8.9	494.43	124.67	51,350,000	53,610,000
December (high service),	176	00	72.33	42	40	16.24	88.57	151,352	25,573	13,079	8.6	585.19	122.45	59,690,000	62,320,000
Totals and averages, high service,	440	00	183.69	49	85	18.78	202.47	332,936	166,820	28,936	8.7	608.13	124.33	62,980,000	65,760,000
Totals and averages, low service,	486	05	203.11	8	30	1.40	204.51	189,856	120,213	16,153	8.5	1,077.18	48.13	43,190,000	45,090,000

TABLE No. 15. — *Statement of Operations of Engine No. 3 at Chestnut Hill High-service Pumping Station for the Year 1901.*

[This engine was designed for the high service, but was used for low service, except as noted.]

MONTHS.	Total Pumping Time.		Amount pumped, 3.03 Per Cent. allowed for Slip (Million Gallons).	Amount of Coal consumed (Pounds).	Coal consumed by Reserve Boiler, which also furnished Steam for Electric Lighting Plant (Pounds).	Amount of Ashes and Clinkers (Pounds).	Per Cent. of Ashes and Clinkers.	Quantity pumped per Pound of Coal, no Deduction for Heating or Lighting (Gallons).	Average Lift (Feet).	Duty in Foot-pounds per 100 Pounds of Coal, no Deduction for Heating or Lighting, 3.03 Per Cent. allowed for Slip.	Duty in Foot-pounds per 100 Pounds of Coal, on Basis of Plunger Displacement, no Deduction for Heating or Lighting.
	Hrs.	Min.									
January (high service),	9	30	9.21	10,045	325	850	8.5	916.87	136.14	103,980,000	107,220,000
January,	151	35	141.35	100,920	23,513	10,058	10.0	1,400.61	65.04	75,880,000	78,250,000
February,	-		-	-	-	-	-	-	-	-	-
March (high service),	175	15	178.57	176,381	5,275	16,831	9.5	1,012.41	126.12	106,360,000	109,680,000
March,	165	30	158.77	109,035	-	11,957	11.0	1,456.14	71.81	87,100,000	89,820,000
April,	180	15	161.60	107,775	7,764	13,152	12.2	1,499.42	67.59	84,420,000	87,050,000
May,	3	50	3.91	*-	-	-	-	-	40.53	-	-
June,	204	50	178.95	115,729	14,218	13,818	11.9	1,546.28	67.13	86,460,000	89,160,000
July (high service),	353	40	349.64	312,731	16,785	33,767	10.8	1,118.02	125.06	116,470,000	120,100,000
July,	1	00	1.00	3,055	-	230	7.5	327.33	67.70	18,460,000	19,040,000
August (high service),	77	45	75.96	66,653	-	6,721	13.6	1,139.63	125.30	118,950,000	122,660,000
September,	-		-	-	-	-	-	-	-	-	-
October,	-		-	-	-	-	-	-	-	-	-
November (high service),	48	55	49.81	46,446	3,486	4,378	9.4	1,072.37	125.97	112,530,000	116,040,000
December (high service),	353	30	353.38	309,901	5,460	31,617	10.2	1,140.30	124.61	118,360,000	122,050,000
Totals and averages, high service,	1,018	35	1,016.57	922,157	31,331	94,164	10.2	1,102.38	125.25	115,010,000	118,600,000
Totals and averages, low service,	707	00	645.58	436,514	45,495	49,210	11.3	1,478.94	67.77	83,490,000	86,090,000

* Coal used charged to Engine No. 4.

TABLE No. 16.—*Statement of Operations of Engine No. 4, at Chestnut Hill High-service Pumping Station for the Year 1901.*

MONTHS.	Total Pumping Time.		Amount pumped, 1.47 Per Cent. allowed for Slip (Million Gallons).	Amount of Coal consumed (Pounds).	Amount of Ashes and Clinkers (Pounds).	Per Cent. of Ashes and Clinkers.	Quantity pumped per Pound of Coal, no Deduction for Heating or Lighting (Gallons).	Average Lift (Feet).	Duty in Foot-pounds per 100 Pounds of Coal, no Deduction for Heating or Lighting, 1.47 Per Cent. allowed for Slip.	Duty in Foot-pounds per 100 Pounds of Coal, on Basis of Plunger Displacement, no Deduction for Heating or Lighting.	SUMMARY OF ENGINES Nos. 1, 2, 3 AND 4.	
	Hrs.	Min.									Total Amount pumped, Allowance made for Slip (Million Gallons).	Daily Average Amount pumped (Million Gallons).
January,	734	25	825.17	594,251	58,743	9.9	1,388.58	125.26	144,890,000	147,060,000	975.73	31.475
February,	672	00	758.21	586,627	55,706	9.5	1,292.49	126.18	135,850,000	137,890,000	758.21	27.079
March,	571	05	611.54	453,082	40,446	8.9	1,349.73	126.14	141,820,000	143,950,000	960.53	30.985
April,	719	15	753.96	563,250	56,698	10.1	1,338.59	124.96	139,340,000	141,430,000	926.19	30.873
May,	740	30	792.35	592,084	59,265	10.0	1,338.24	125.30	139,680,000	141,780,000	808.09	26.067
June,	743	30	822.05	615,387	59,667	9.7	1,335.83	126.43	140,680,000	142,790,000	1,063.99	35.466
July,	386	50	447.68	333,514	31,389	9.4	1,342.31	126.95	141,950,000	144,080,000	870.04	28.066
August,	665	50	735.65	529,801	50,457	9.5	1,388.54	126.92	146,800,000	149,000,000	828.96	26.741
September,	718	10	804.50	590,070	56,121	9.5	1,363.40	126.91	144,130,000	146,290,000	832.96	27.765
October,	744	00	834.74	619,188	55,274	8.9	1,348.12	127.16	142,800,000	144,940,000	929.65	29.989
November,	671	00	747.87	533,777	46,975	8.8	1,401.09	126.08	147,150,000	149,360,000	806.55	26.885
December,	384	45	450.39	335,030	30,618	9.1	1,344.33	128.66	144,080,000	146,240,000	892.34	28.785
Totals and averages,	7,751	20	8,584.11	6,846,061	601,354	9.5	1,352.67	126.31	142,320,000	144,450,000	10,653.24	29.187

TABLE No. 17. — *Statement of Operations of Engines Nos. 5, 6 and 7 at Chestnut Hill Low-service Pumping Station for the Year [illegible].*

MONTHS.	ENGINE No. 5. Total Pumping Time.		ENGINE No. 5. Amount pumped, 1.53 Per Cent. allowed for Slip (Million Gallons).	ENGINE No. 6. Total Pumping Time.		ENGINE No. 6. Amount pumped, 1.32 Per Cent. allowed for Slip (Million Gallons).	ENGINE No. 7. Total Pumping Time.		ENGINE No. 7. Amount pumped, 1.35 Per Cent. allowed for Slip (Million Gallons).	Total Amount pumped, Million Gallons.	Daily Average Amount pumped, Million Gallons.	Total Amount of Coal consumed, Pounds.	Per Cent of Ashes and Clinkers.	[illegible]	[illegible] Engine No. 5.	[illegible] Engine No. 6.	[illegible] Engine No. 7.	[illegible]	[illegible]
	Hrs.	Min.		Hrs.	Min.		Hrs.	Min.											
January,	691	05	735.99	734	15	829.31	568	40	643.19	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
February,	669	50	817.27	672	00	810.26	666	55	705.60	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
March,	743	15	862.91	579	15	661.76	744	00	827.68	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
April,	444	41	595.89	507	20	660.69	517	20	648.42	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
May,	523	55	657.11	641	45	814.35	361	40	485.58	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
June,	248	35	331.86	718	05	979.34	478	55	656.01	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
July,	660	55	838.00	562	45	706.14	613	55	777.61	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
August,	561	35	774.24	436	45	598.18	614	50	840.07	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
September,	534	35	740.74	194	45	258.22	709	35	906.66	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
October,	744	00	1,055.64	338	05	460.77	504	35	708.78	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
November,	347	25	447.86	663	40	921.46	606	05	882.58	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
December,	736	55	887.31	713	35	854.82	675	20	700.80	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Totals and averages,	6,901	46	8,794.82	6,762	15	8,573.25	7,060	50	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

TABLE No. 18. — *Statement of Operations of Engine No. 8 at Spot Pond Pumping Station for the Year 1901.*

MONTHS.	Total Pumping Time.	Amount pumped, 2.02 Per Cent. allowed for Slip (Million Gallons).	Amount of Coal consumed (Pounds).	Amount of Ashes and Clinkers (Pounds).	Per Cent. of Ashes and Clinkers.	Quantity pumped per Pound of Coal, no Deduction for Heating or Lighting (Gallons).	Average Lift (Feet).	Duty in Foot-pounds per 100 Pounds of Coal, no Deduction for Heating or Lighting, 2.02 Per Cent. allowed for Slip.	Duty in Foot-pounds per 100 Pounds of Coal, on Basis of Plunger Displacement, no Deduction for Heating or Lighting.
	Hrs. Min.								
January,	-	-	-	-	-	-	-	-	-
February,	61 20	26.67	29,542	2,597	8.8	902.78	115.77	87,060,000	88,850,000
March,	-	-	-	-	-	-	-	-	-
April,	-	-	-	-	-	-	-	-	-
May,	184 00	79.67	85,959	9,036	10.5	926.84	112.68	87,000,000	88,790,000
June,	-	-	-	-	-	-	-	-	-
July,	-	-	-	-	-	-	-	-	-
August,	-	-	-	-	-	-	-	-	-
September,	367 50	161.55	148,638	16,173	10.9	1,086.87	114.63	103,780,000	105,920,000
October,	190 40	84.00	80,836	7,720	9.6	1,039.14	115.74	100,190,000	102,250,000
November,	-	-	-	-	-	-	-	-	-
December,	-	-	-	-	-	-	-	-	-
Totals and averages,	803 50	351.89	344,975	35,526	10.3	1,020.04	114.54	97,320,000	99,320,000

TABLE No. 19. — *Statement of Operations of Engine No. 9 at Spot Pond Pumping Station for the Year 1901.*

MONTHS.	Total Pumping Time. Hrs.	Total Pumping Time. Min.	Amount pumped. 1.63 Per Cent. allowed for Slip (Million Gallons.)	Amount of Coal consumed (Pounds).	Amount of Ashes and Clinkers (Pounds).	Per Cent. of Ashes and Clinkers.	Quantity pumped per Pound of Coal, no Deduction for Heating or Lighting (Gallons).	Average Lift (Feet).	Duty in Foot-pounds per 100 Pounds of Coal, no Deduction for Heating or Lighting, 1.63 Per Cent. allowed for Slip.	Duty in Foot-pounds per 100 Pounds of Coal on Basis of Plunger Displacement, no Deduction for Heating or Lighting.
January,	239	05	198.76	217,834	25,258	11.6	912.44	121.84	92,610,000	94,150,000
February,	204	50	171.12	170,639	15,154	8.9	1,002.82	121.87	101,800,000	103,490,000
March,	249	00	206.25	194,600	18,026	9.3	1,059.87	120.90	106,740,000	108,510,000
April,	208	25	175.36	160,567	14,811	9.2	1,092.13	116.39	105,890,000	107,650,000
May,	181	30	150.88	129,276	11,933	9.2	1,167.12	118.74	115,440,000	117,360,000
June,	318	45	262.37	212,950	21,630	10.2	1,232.07	118.98	122,110,000	124,140,000
July,	346	20	292.00	222,765	20,124	9.0	1,310.80	119.06	130,000,000	132,160,000
August,	321	05	263.15	215,279	20,272	9.4	1,222.37	119.65	121,830,000	123,850,000
September,	89	15	74.03	56,475	5,712	10.1	1,310.85	120.50	131,580,000	133,760,000
October,	180	00	149.41	117,029	10,848	9.3	1,276.69	120.83	128,500,000	130,630,000
November,	270	35	221.67	166,585	16,680	10.0	1,330.67	119.02	131,930,000	134,120,000
December,	401	25	249.53	212,022	18,677	8.8	1,176.91	117.70	115,390,000	117,310,000
Totals and averages,	3,010	15	2,414.53	2,076,021	199,125	9.6	1,163.06	119.50	115,780,000	117,700,000

TABLE No. 20.—*Average Daily Consumption of Water in Cities and Towns in the Metropolitan Water District and the Town of Swampscott, supplied wholly or in Part by the Metropolitan Water Works (1901).*

MONTHS.	Supplied by Metropolitan Works (Million Gallons).	Supplied from Local Sources (Million Gallons).*	Total (Million Gallons).	Estimated Population.	Consumption per Inhabitant (Gallons).
January,	107.930	.631	108.561	834,200	130
February,	113.967	.723	114.690	836,200	137
March,	101.509	1.213	102.722	838,200	123
April,	90.010	.561	90.571	840,200	108
May,	91.844	.566	92.410	842,200	110
June,	98.932	.672	99.604	844,000	118
July,	102.410	.782	103.192	845,900	122
August,	98.581	.700	99.281	847,700	117
September,	98.088	.726	98.814	849,500	116
October,	99.645	.481	100.126	851,300	118
November,	98.336	-	98.336	853,200	115
December,	110.277	-	110.277	855,000	129
For the year,	100.904	.588	101.492	844,800	120

* The town of Stoneham was supplied by the Wakefield Water Company until October 21, and a portion of the supply of the city of Medford was taken from Wright's Pond from February 25 to March 27.

TABLE No. 21.—*Average Daily Consumption of Water from the Low Service (1901).*

MONTHS.	Southern Low-service of Boston, excluding East Boston and Charlestown (Million Gallons).	SOMERVILLE, CHELSEA, EVERETT, MALDEN, MEDFORD, CHARLESTOWN, EAST BOSTON, MELROSE AND ARLINGTON.			Total Low-service Consumption (Million Gallons).
		Supplied from Metropolitan Sources (Million Gallons).	Gravity Supply to Medford from Wright's Pond (Million Gallons).	Total Northern Low-service Consumption (Million Gallons).	
January,	43.649	30.588	-	30.588	74.237
February,	46.017	33.372	.099	33.471	79.488
March,	41.946	26.751	.594	27.345	69.291
April,	38.460	20.238	-	20.238	58.698
May,	36.581	21.717	-	21.717	58.298
June,	37.434	25.694	-	25.694	63.128
July,	36.852	27.568	-	27.568	64.420
August,	37.104	25.881	-	25.881	62.985
September,	37.322	25.780	-	25.780	63.102
October,	38.580	26.276	-	26.276	64.856
November,	38.527	25.472	-	25.472	63.999
December,	44.947	28.373	-	28.373	73.320
For the year,	39.754	26.443	.058	26.501	66.255

Table No. 22. — *Average Daily Consumption of Water from the Southern High Service (1901).*

MONTHS.	Pumped at Chestnut Hill High-service Station for the Supply of Boston, Quincy, Watertown and Belmont (Million Gallons).*	MONTHS.	Pumped at Chestnut Hill High-service Station for the Supply of Boston, Quincy, Watertown and Belmont (Million Gallons) *
January,	26.577	August,	26.456
February,	26.646	September,	26.479
March,	25.433	October,	26.655
April,	24.751	November,	26.382
May,	25.253	December,	28.460
June,	27.018	For the year,	26.496
July,	27.806		

* This does not include water pumped from southern high-service mains for southern extra high-service, at the West Roxbury pumping station.

Table No. 23. — *Average Daily Consumption of Water, in Million Gallons, from the Northern High Service, supplying Revere, Winthrop, Swampscott, Nahant, Stoneham and Breed's Island, and the Higher Portions of Chelsea, Everett, Malden, Medford, Melrose and Somerville (1901).*

MONTHS.	Pumped by Wakefield Water Co. for Stoneham.	Pumped at East Boston Station.	Pumped at Spot Pond Station.	Total Northern High-service Pumpage.	Storage in Fells Reservoir.	Total Northern High-service Consumption.
January,	.631	.055	6.411	7.097	+.062	7.159
February,	.624	.070	7.064	7.758	+.073	7.831
March,	.619	.060	6.653	7.332	—.024	7.308
April,	.561	.058	5.846	6.465	+.044	6.509
May,	.566	.053	7.437	8.056	+.215	8.271
June,	.672	.037	8.746	9.455	—.760	8.695
July,	.782	-	9.419	10.201	—.041	10.160
August,	.700	-	8.488	9.188	+.001	9.189
September,	.726	-	7.852	8.578	+.025	8.603
October,	.481	-	7.529	8.010	+.010	8.020
November,	-	-	7.389	7.389	+.019	7.408
December,	-	-	8.049	8.049	—.084	7.965
For the year,	.530	.027	7.579	8.136	—.038	8.098

Stoneham connected with Metropolitan Water Works mains October 21, at 10.15 A.M. Pumping at East Boston station discontinued June 20, at 8.30 P.M.

Table No. 24. — *Average Daily Consumption of Water from the Southern Extra High Service in West Roxbury and the Northern Extra High Service in Arlington (1901).*

MONTHS.	Southern Extra High Service, West Roxbury (Gallons).	Northern Extra High Service, Arlington (Gallons).
January,	325,000	263,000
February,	433,000	292,000
March,	430,000	260,000
April,	381,000	232,000
May,	319,000	269,000
June,	383,000	379,000
July,	381,000	426,000
August,	284,000	367,000
September,	296,000	334,000
October,	272,000	323,000
November,	258,000	289,000
December,	261,000	271,000
For the year,	334,000	309,000

Table No. 25. — *Consumption of Water in the Metropolitan Water District, as constituted December 31, 1901, and the Town of Swampscott, 1893–1901.*

[Gallons per Day.]

MONTHS.	1893.	1894.	1895.	1896.	1897.
January,	74,997,000	67,282,000	68,730,000	82,677,000	85,143,000
February,	71,638,000	68,699,000	80,119,000	86,750,000	88,695,000
March,	67,410,000	62,460,000	69,296,000	85,359,000	82,486,000
April,	62,048,000	57,432,000	62,636,000	77,229,000	79,639,000
May,	60,743,000	60,338,000	64,886,000	73,026,000	76,451,000
June,	63,025,000	67,981,000	69,511,000	77,218,000	77,567,000
July,	68,939,000	73,241,000	69,265,000	79,563,000	85,104,000
August,	66,619,000	67,632,000	71,819,000	78,138,000	83,725,000
September,	64,315,000	66,795,000	73,339,000	73,824,000	83,906,000
October,	63,443,000	62,423,000	66,707,000	71,423,000	79,202,000
November,	60,900,000	61,949,000	64,596,000	71,641,000	72,471,000
December,	66,454,000	64,856,000	70,200,000	79,199,000	76,344,000
Average for the year,	65,867,000	65,078,000	69,188,000	78,032,000	80,474,000
Population,	714,623	734,512	754,401	776,947	799,498
Consumption per inhabitant,	92.2	88.6	91.7	100.4	100.7

Table No. 25 — *Concluded.*

MONTHS.	1898.	1899.	1900.	1901.
January,	83,628,000	96,200,000	99,806,000	111,008,000
February,	87,211,000	103,204,000	98,684,000	117,172,000
March,	85,172,000	89,920,000	97,474,000	105,187,000
April,	76,269,000	86,185,000	89,145,000	92,968,000
May,	76,304,000	89,041,000	87,433,000	95,212,000
June,	88,024,000	97,237,000	98,059,000	102,857,000
July,	87,762,000	96,398,000	107,186,000	106,256,000
August,	87,096,000	91,662,000	102,153,000	102,116,000
September,	87,862,000	91,092,000	103,038,000	101,467,000
October,	81,452,000	89,264,000	97,958,000	102,856,000
November,	77,898,000	86,432,000	93,302,000	100,867,000
December,	86,073,000	85,558,000	97,539,000	112,829,000
Average for the year,	83,808,000	91,773,000	97,659,000	104,179,000
Population,	822,039	844,585	867,131	890,700
Consumption per inhabitant,	101.3	108.7	112.6	117.0

Table No. 26. — *Consumption of Water in the Metropolitan Water District and Swampscott, 1890–1901.*

YEAR.	Water Consumption (Gallons per Day).	Population.	Consumption per Inhabitant (Gallons per Day).
1890,	47,824,000	654,957	73.0
1891,	52,947,000	674,846	78.5
1892,	57,987,000	694,735	83.5
1893,	65,867,000	714,623	92.2
1894,	65,078,000	734,512	88.6
1895,	69,188,000	754,401	91.7
1896,	78,032,000	776,947	100.4
1897,	80,474,000	799,493	100.7
1898,	83,808,000	822,039	101.3
1899,	91,773,000	844,585	108.7
1900,	97,659,000	867,131	112.6
1901,	104,185,000	890,700	117.0

Increase in decade from 1891 to 1901: —

In population,	32 per cent.
In consumption per inhabitant,	49 per cent.
In total consumption,	97 per cent.

Note relating to Chemical Examinations of Water, Tables Nos. 27–33.

The chemical examinations contained in the tables were made by the State Board of Health. Colors have been determined by the Nessler standard, but the corresponding values by the platinum standard are also given, for the purpose of comparison with colors determined in the laboratory of the Metropolitan Water and Sewerage Board, as given in subsequent tables. The odor recorded is taken in such a way that it is a much stronger odor than would be noticed in samples drawn directly from a tap or collected directly from a reservoir. In nearly all cases the samples are collected and examined monthly; in the case of the Sudbury Reservoir, however, they are made weekly.

Table No. 27. — *Chemical Examinations of Water from the Nashua River above the Temporary Dam at Clinton.*

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.				Odor.		Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.		Cold.	Hot.	Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.		
				Nessler Standard.	Transformed to Platinum Standard.						Total.	Dissolved.	Suspended.					
	1901.																	
34287	Jan. 1	V. slight.	V. slight.	.33	.35	Distinctly vegetable.	Decidedly vegetable.	3.45	1.25	.0016	.0148	.0136	.0012	.24	.0100	.0000	.49	1.4
34654	Feb. 4	V. slight.	V. slight.	.24	.29	Distinctly vegetable.	Distinctly vegetable and musty.	3.50	1.10	.0006	.0190	.0138	.0052	.24	.0130	.0001	.34	1.1
34971	March 4	Decided.	Cons.	.25	.29	None.	Faintly unpleasant.	4.05	1.25	.0038	.0202	.0146	.0056	.30	.0130	.0001	.34	1.1
35296	April 1	Slight.	Slight.	.32	.34	None.	Faintly vegetable.	2.90	1.15	.0004	.0166	.0152	.0014	.16	.0100	.0000	.52	0.6
35553	April 29	Slight.	Slight.	.36	.37	None.	Distinctly vegetable.	2.65	1.25	.0014	.0150	.0126	.0024	.16	.0060	.0000	.42	0.5
35828	June 3	Slight.	Slight.	.50	.46	Distinctly vegetable.	Distinctly vegetable.	3.05	1.20	.0006	.0142	.0112	.0030	.12	.0070	.0000	.56	0.8
36195	July 1	Slight.	Slight.	.33	.35	Faintly vegetable.	Distinctly vegetable.	3.75	1.45	.0020	.0204	.0170	.0034	.24	.0050	.0007	.32	1.4
36647	Aug. 5	Slight.	Slight.	.50	.46	None.	Faintly vegetable.	3.70	1.80	.0026	.0212	.0168	.0044	.19	.0010	.0001	.52	1.4
37076	Sept. 3	Slight.	Cons.	.33	.35	Faintly vegetable.	Distinctly vegetable.	4.50	1.80	.0030	.0172	.0168	.0004	.19	.0040	.0002	.57	1.3
37418	Sept. 30	Slight.	Slight.	.29	.32	Faintly vegetable.	Distinctly vegetable.	4.30	1.40	.0014	.0234	.0192	.0042	.25	.0050	.0002	.41	1.6
37828	Nov. 4	Decided.	Slight.	.34	.35	Distinctly vegetable.	Decidedly vegetable.	4.30	1.60	.0020	.0208	.0172	.0036	.27	.0040	.0001	.46	1.3
38124	Dec. 2	V. slight.	Slight.	.43	.41	Distinctly vegetable.	Decidedly vegetable.	4.80	2.00	.0010	.0164	.0146	.0018	.30	.0060	.0001	.53	1.1
Av...	....	....	....	.35	.36	....	....	3.75	1.44	.0017	.0183	.0152	.0031	.22	.0070	.0001	.46	1.1

TABLE No. 28. — *Chemical Examinations of Water from Framingham Reservoir No. 3.*

[Parts per 100,000.]

Number.	Date of Collection.	APPEARANCE.				ODOR.		RESIDUE ON EVAPORATION.		AMMONIA.				Chlorine.	NITROGEN AS		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	COLOR.		Cold.	Hot.	Total.	Loss on Ignition.	Free.	ALBUMINOID.				Nitrates.	Nitrites.		
				NesslerStandard.	Transformed to Platinum Standard.						Total.	Dissolved.	Suspended.					
	1901.																	
34276	Jan. 1	None.	Slight.	.35	.36	None.	Faintly vegetable.	4.35	1.30	.0030	.0182	.0136	.0046	.26	.0190	.0000	.61	1.7
34651	Feb. 4	V. slight.	V. slight.	.31	.34	Faintly vegetable.	Faintly vegetable.	4.40	1.70	.0020	.0150	.0140	.0010	.23	.0220	.0000	.48	2.0
34960	March 4	V. slight.	Slight.	.28	.32	None.	Faintly vegetable.	4.70	1.65	.0024	.0144	.0128	.0016	.32	.0240	.0001	.43	2.0
35295	April 1	Slight.	Slight.	.30	.33	None.	Faintly vegetable.	4.15	1.65	.0036	.0180	.0136	.0044	.24	.0280	.0000	.41	1.1
35536	April 29	Slight.	Slight.	.26	.30	Faintly vegetable	Faintly unpleasant and fishy.	3.50	1.25	.0020	.0162	.0142	.0020	.22	.0160	.0000	.32	1.1
35823	June 3	Slight.	Slight.	.30	.33	None.	Faintly vegetable.	3.75	1.25	.0024	.0146	.0140	.0006	.27	.0310	.0002	.48	1.6
36186	July 1	V. slight.	V. slight.	.22	.27	Faintly vegetable.	Distinctly vegetable.	4.80	1.70	.0012	.0160	.0154	.0006	.26	.0210	.0005	.36	1.4
36637	Aug. 5	None.	Slight, cyclops.	.20	.26	Distinctly vegetable.	Decidedly vegetable.	4.20	1.65	.0022	.0150	.0132	.0018	.24	.0110	.0002	.37	1.6
37048	Sept. 3	V. slight.	Slight.	.12	.20	Faintly vegetable.	Distinctly vegetable.	5.40	1.35	.0024	.0174	.0130	.0044	.27	.0050	.0001	.35	1.7
37408	Sept. 30	V. slight.	Slight.	.18	.24	Faintly vegetable.	Distinctly vegetable.	4.00	1.80	.0008	.0162	.0134	.0028	.22	.0040	.0001	.36	1.7
37815	Nov. 4	V. slight.	V. slight	.11	.19	Faintly vegetable.	Distinctly vegetable.	3.75	1.50	.0014	.0192	.0180	.0012	.22	.0020	.0000	.38	1.4
38185	Dec. 2	Slight.	Slight.	.26	.30	Faintly vegetable.	Distinctly vegetable.	6.90	2.10	.0020	.0170	.0152	.0018	.28	.0040	.0000	.45	1.3
Av.	....	....	....	.24	.29	....	....	4.49	1.57	.0021	.0164	.0142	.0022	.25	.0156	.0001	.42	1.5

TABLE NO. 29. — *Chemical Examinations of Water from Lake Cochituate.*

[Parts per 100,000.]

		APPEARANCE.				ODOR.		RESIDUE ON EVAPORATION		AMMONIA.					NITROGEN AS			
				COLOR.							ALBUMINOID.							
Number.	Date of Collection.	Turbidity.	Sediment.	Nessler Standard.	Transformed to Platinum Standard.	Cold.	Hot.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.
	1901.																	
34283	Jan. 1	V. slight.	Slight.	.20	.26	Distinctly vegetable.	Decidedly vegetable.	4.60	1.10	.0102	.0218	.0184	.0034	.43	.0060	.0004	.40	2.1
34652	Feb. 4	V. slight.	Slight, cyclops.	.24	.29	Faintly vegetable.	Distinctly vegetable.	5.10	1.60	.0054	.0202	.0180	.0022	.45	.0090	.0001	.40	2.0
34961	March 4	V. slight.	V. slight.	.22	.27	Faintly vegetable.	Distinctly vegetable.	5.10	1.40	.0022	.0208	.0188	.0020	.49	.0100	.0002	.44	2.2
35294	April 1	V. slight.	Slight.	.21	.27	None.	Faintly vegetable.	4.70	1.70	.0034	.0208	.0174	.0034	.39	.0200	.0001	.40	2.1
35543	April 29	Slight.	Cons.	.25	.29	Faintly vegetable.	Distinctly vegetable.	5.00	1.75	.0048	.0282	.0234	.0048	.48	.0200	.0002	.50	1.8
35825	June 3	Slight.	Cons.	.42	.40	Faintly vegetable.	Distinctly vegetable.	4.90	1.75	.0032	.0258	.0212	.0046	.42	.0170	.0004	.62	2.2
36193	July 1	Slight.	Cons.	.34	.35	None.	None.	5.40	2.15	.0088	.0296	.0240	.0056	.47	.0110	.0005	.55	2.1
36636	Aug. 5	None.	V. slight, cyclops.	.28	.32	None.	Faintly vegetable.	4.85	1.95	.0018	.0254	.0216	.0038	.39	.0100	.0004	.57	2.1
37063	Sept. 3	Slight.	Cons.	.25	.29	Faintly vegetable.	Distinctly vegetable.	6.90	2.50	.0014	.0244	.0196	.0048	.31	.0030	.0002	.57	2.3
37427	Sept. 30	V. slight.	Slight, cyclops.	.24	.29	Faintly vegetable.	Distinctly vegetable.	5.35	2.55	.0010	.0246	.0210	.0036	.32	.0040	.0001	.48	2.2
37820	Nov. 4	V. slight.	Sl't, cons. cyclops.	.20	.26	Distinctly vegetable.	Decidedly vegetable.	5.10	1.90	.0024	.0230	.0184	.0046	.39	.0060	.0000	.40	2.1
38198	Dec. 2	V. slight.	V. slight.	.24	.29	Distinctly vegetable.	Decidedly vegetable.	5.10	2.00	.0064	.0218	.0176	.0042	.43	.0070	.0003	.38	2.1
Av...	....	....	....	.26	.30	....	....	5.17	1.86	.0042	.0239	.0200	.0039	.41	.0102	.0002	.48	2.1

TABLE No. 30. — *Chemical Examinations of Water from Spot Pond, Stoneham.*

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.				Odor.		Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
				Color.							Albuminoid.							
		Turbidity.	Sediment.	NesslerStandard.	Transformed to Platinum Standard.	Cold.	Hot.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1901.																	
34264	Jan. 1	V. slight.	Slight, cyclops.	.07	.18	None.	None.	5.25	1.35	.0032	.0234	.0192	.0042	.34	.0040	.0000	.35	2.2
34642	Feb. 4	None.	V. slight.	.08	.15	Faintly vegetable.	Faintly vegetable.	5.35	1.45	.0008	.0158	.0128	.0030	.30	.0050	.0000	.33	2.0
34947	March 4	V. slight.	Slight.	.12	.20	Faintly unpleasant.	Distinctly unpleasant.	5.60	1.45	.0016	.0212	.0192	.0020	.34	.0040	.0001	.35	2.1
35285	April 1	V. slight.	Cons.	.10	.18	Faintly unpleasant.	Decidedly unpleasant and fishy.	4.75	1.25	.0012	.0180	.0144	.0036	.28	.0030	.0001	.35	2.3
35597	May 6	Slight.	Cons.	.11	.19	Distinctly vegetable.	Distinctly unpleasant and fishy.	4.55	1.35	.0008	.0156	.0126	.0030	.28	.0050	.0001	.30	2.1
35889	June 10	V. slight.	Slight.	.06	.11	None.	None.	4.30	1.20	.0034	.0174	.0148	.0026	.30	.0050	.0001	.25	2.0
36251	July 8	V. slight.	V. slight.	.06	.11	None.	None.	4.50	1.45	.0000	.0154	.0138	.0016	.27	.0030	.0001	.27	1.3
36634	Aug. 5	None.	Slight.	.06	.11	None.	Faintly vegetable.	4.75	1.85	.0008	.0152	.0122	.0030	.28	.0040	.0002	.30	2.1
37117	Sept. 9	None.	V. slight.	.08	.15	Distinctly vegetable.	Distinctly vegetable.	4.60	1.60	.0006	.0136	.0130	.0006	.24	.0050	.0001	.31	2.0
37414	Sept. 30	V. slight.	Slight.	.08	.15	Faintly vegetable.	Distinctly vegetable.	4.50	1.80	.0010	.0168	.0130	.0038	.25	.0050	.0001	.29	2.3
37819	Nov. 4	V. slight.	V. slight.	.08	.15	Faintly vegetable.	Faintly fishy.	4.15	1.55	.0030	.0178	.0160	.0018	.24	.0020	.0000	.31	1.8
38201	Dec. 3	V. slight.	Cons.	.08	.15	Distinctly unpleasant.	Decidedly unpleasant, distinctly fishy.	4.45	1.75	.0006	.0154	.0140	.0014	.29	.0000	.0001	.30	1.7
Av....	....	....	....	.08	.15	....	....	4.73	1.50	.0014	.0171	.0146	.0025	.28	.0042	.0001	.31	2.0

TABLE No. 31. — *Chemical Examinations of Water from a Faucet at the State House, Boston.*

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.				Odor.		Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
				Color.							Albuminoid.							
		Turbidity.	Sediment.	NesslerStandard.	Transformed to Platinum Standard.	Cold.	Hot.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1901.																	
34265	Jan. 1	V. slight.	Slight.	.32	.34	Distinctly vegetable.	Decidedly vegetable.	4.65	1.40	.0026	.0168	.0142	.0026	.32	.0080	.0001	.47	1.8
34640	Feb. 4	V. slight.	V. slight.	.30	.33	Distinctly vegetable.	Distinctly vegetable.	4.60	1.75	.0016	.0132	.0116	.0016	.35	.0270	.0000	.44	1.6
34968	March 5	V. slight.	Slight.	.30	.33	Faintly vegetable.	Distinctly vegetable.	4.85	1.45	.0010	.0158	.0146	.0012	.36	.0230	.0002	.48	1.7
35282	April 1	V. slight.	Slight.	.30	.33	Faintly vegetable.	Distinctly vegetable.	3.90	1.30	.0030	.0152	.0138	.0014	.28	.0290	.0000	.42	1.4
35528	April 29	V. slight.	Slight.	.22	.27	Faintly vegetable.	Distinctly vegetable.	4.00	1.35	.0018	.0142	.0136	.0006	.30	.0300	.0002	.34	1.4
35807	June 3	Slight.	Cons.	.25	.29	None.	Faintly vegetable.	3.85	1.60	.0006	.0156	.0124	.0032	.26	.0370	.0000	.36	1.7
36234	July 5	None.	Slight.	.29	.32	None.	Faintly vegetable.	4.55	1.60	.0010	.0160	.0156	.0004	.27	.0140	.0000	.45	1.7
36629	Aug. 5	None.	Slight.	.24	.29	None.	Distinctly vegetable.	4.65	2.10	.0004	.0140	.0132	.0008	.29	.0090	.0002	.44	2.3
37069	Sept. 4	V. slight.	Slight.	.20	.26	Faintly vegetable.	Distinctly vegetable.	4.90	2.00	.0006	.0182	.0166	.0016	.28	.0050	.0002	.41	1.8
37409	Sept. 30	V. slight.	Slight.	.14	.21	None.	Faintly vegetable.	4.50	1.90	.0000	.0168	.0154	.0014	.32	.0080	.0001	.39	1.7
37842	Nov. 5	V. slight.	V. slight.	.14	.21	Faintly vegetable.	Distinctly vegetable.	4.20	1.65	.0020	.0190	.0168	.0022	.30	.0080	.0000	.43	1.8
38181	Dec. 2	V. slight.	V. slight.	.22	.27	Distinctly vegetable.	Decidedly vegetable.	4.50	1.60	.0006	.0144	.0130	.0014	.31	.0100	.0000	.44	1.4
Av...	....	....	....	.24	.29	....	....	4.43	1.64	.0013	.0158	.0142	.0016	.30	.0173	.0001	.42	1.7

TABLE No. 32. — *Averages of Examinations of Water from Various Parts of the Metropolitan Water Works.* [illegible]

(Parts per 100,000.)

LOCALITY.	Color.		Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen consumed.	Hardness.
	Nessler Standard.	Platinum Standard.	Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.		
						Total.	Dissolved.	Suspended.					
Quinepoxet River, Holden,	.47	.44	3.60	1.68	.0016	.0220	.0142	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Stillwater River, Sterling,	.42	.40	3.23	1.43	.0015	.0184	.0161	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Nashua River, Clinton,	.35	.36	3.75	1.44	.0017	.0183	.0152	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Marlborough (Walker's) Brook,	.31	.34	16.34	5.01	.1130	.0471	.0334	.0137	2.16	[illegible]	[illegible]	[illegible]	[illegible]
Marlborough Brook filter beds, effluent,	.09†	.17	14.30	-	.0504	.0190	-		1.27	[illegible]	[illegible]	[illegible]	[illegible]
Sudbury Reservoir, surface,*	.25	.29	4.03	1.51	.0026	.0160	.0148	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Sudbury Reservoir, mid-depth,*	.26	.30	4.08	1.52	.0024	.0164	.0136	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Sudbury Reservoir, bottom,*	.25	.29	4.14	1.54	.0038	.0162	.0136	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Framingham Reservoir No. 3, near dam,	.24	.29	4.49	1.57	.0021	.0164	.0142	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Hopkinton Reservoir, influent,	1.78	1.35	7.24	4.07	.0049	.0428	.0408	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Hopkinton Reservoir, surface,	.59	.51	4.12	1.77	.0039	.0240	.0202	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Hopkinton Reservoir, bottom,	.55	.49	4.42	1.82	.0146	.0224	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Ashland Reservoir, influent,	1.66	1.26	6.86	3.42	.0062	.0440	.0407	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Ashland Reservoir, surface,	.65	.55	4.07	1.77	.0026	.0261	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Ashland Reservoir, bottom,	.59	.51	4.21	1.80	.0020	.0227	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Framingham Reservoir No. 2, influent,	1.01	.82	5.56	2.46	.0042	.0220	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Framingham Reservoir No. 2, near dam,	.90	.70	5.27	2.27	.0050	.0274	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Lake Cochituate,	.26	.30	5.17	1.86	.0042	.0220	[illegible]	[illegible]	.41	[illegible]	[illegible]	[illegible]	[illegible]
Terminal chamber, Sudbury Aqueduct,	.27	.31	4.02	1.47	.0020	.0165	.0147	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Spot Pond,	.08	.15	4.73	1.50	.0014	.0171	.0146	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Tap at State House,	.24	.29	4.43	1.64	.0018	.0158	.0142	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

* These examinations were made weekly.

† Exclusive of March.

TABLE No. 33. — *Chemical Examinations of Water from a Faucet in Boston, from 1888 to 1901.*

[Parts per 100,000.]

YEARS.	COLOR.		RESIDUE ON EVAPORATION.		AMMONIA.				Chlorine.	NITROGEN AS		Oxygen Consumed.	Hardness.
						ALBUMINOID.							
	Nessler Standard.	Platinum Standard.	Total.	Loss on Ignition.	Free.	Total.	Dis-solved.	Sus-pended.		Nitrates.	Nitrites.		
1888, . .	.38	.38	4.94	1.58	.0012	.0215	-	-	.40	.0183	.0002	-	-
1889, . .	.51	.46	4.71	1.48	.0005	.0199	.0176	.0023	.42	.0272	.0002	-	-
1890, . .	.35	.36	4.70	1.25	.0003	.0169	.0148	.0021	.42	.0241	.0001	-	2.2
1891, . .	.37	.38	4.39	1.63	.0005	.0161	.0136	.0025	.37	.0227	.0001	-	1.7
1892, . .	.37	.37	4.70	1.67	.0007	.0168	.0138	.0030	.41	.0210	.0001	-	1.9
1893, . .	.61	.53	4.54	1.84	.0010	.0174	.0147	.0027	.38	.0143	.0001	.60	1.8
1894, . .	.69	.58	4.64	1.83	.0006	.0169	.0150	.0019	.41	.0106	.0001	.63	1.7
1895, . .	.72	.59	4.90	2.02	.0006	.0197	.0175	.0022	.40	.0171	.0001	.69	0.7
1896, . .	.49	.45	4.29	1.67	.0005	.0165	.0142	.0023	.37	.0155	.0001	.56	1.4
1897, . .	.65	.55	4.82	1.84	.0009	.0193	.0177	.0016	.40	.0137	.0001	.64	1.6
1898, . .	.41	.40	4.19	1.60	.0008	.0152	.0136	.0016	.29	.0097	.0001	.44	1.4
1899, . .	.23	.28	3.70	1.30	.0006	.0136	.0122	.0014	.24	.0137	.0001	.35	1.1
1900, . .	.24	.29	3.80	1.20	.0012	.0157	.0139	.0018	.25	.0076	.0001	.38	1.3
1901, . .	.24	.29	4.43	1.64	.0013	.0158	.0142	.0016	.30	.0173	.0001	.42	1.7

TABLE No. 34. — *Microscopical Examinations of Water from Various Parts of the Metropolitan Water Works, 1901 (Means of Weekly Determinations).*

Nashua River at Head of Wachusett Aqueduct.

[Standard units per cubic centimeter.]

MONTHS.	ORGANISMS.	AMORPHOUS.	Principal Organisms.
	Surface.	Surface.	
January, ...	38	34	Diatomaceæ.
February, ...	19	29	Infusoria.
March, ...	51	60	Diatomaceæ. Infusoria.
April, ...	32	62	Infusoria.
May, ...	88	41	Diatomaceæ.
June, ...	96	44	Diatomaceæ. Infusoria. Rotifera.
July, ...	151	58	Diatomaceæ. Chlorophyceæ. Infusoria. Rotifera.
August, ...	87	64	Rotifera.
September, ...	55	57	Infusoria. Rotifera. Crenothrix.
October, ...	96	56	Infusoria. Rotifera.
November, ...	30	41	Diatomaceæ.
December, ...	40	35	Diatomaceæ.
Mean, ...	65	48	

[illegible]

[illegible]

[Standard units per cubic centimeter.]

MONTHS.	Organisms.				Amorphous.				Principal Organisms in the [illegible].
	Surface.	Mid-depth.	Bottom.	[illegible]	Surface.	Mid-depth.	Bottom.	[illegible]	
January, .	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Diatomaceæ. Infusoria. Rotifera.
February, .	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Infusoria. Rotifera.
March, . .	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Infusoria.
April,	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Diatomaceæ. Infusoria. Rotifera.
May, . .	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Diatomaceæ. Infusoria. Rotifera.
June, . .	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Diatomaceæ. Chlorophyceæ. Cyanophyceæ.
July, . .	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Diatomaceæ. Chlorophyceæ. Cyanophyceæ.
August, . . .	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Diatomaceæ. Cyanophyceæ. Rotifera.
September, .	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Diatomaceæ. Infusoria. Cyanophyceæ. Rotifera.
October, . .	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Diatomaceæ. Infusoria. Cyanophyceæ. Rotifera.
November, .	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Diatomaceæ. Cyanophyceæ.
December, .	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Diatomaceæ. Cyanophyceæ. Rotifera.
Mean, .	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	

Framingham Reservoir No. 3, 1901.

[Standard units per cubic centimeter.]

MONTHS.	Organisms.			Amorphous.			Principal Organisms.
	Surface.	Mid-depth.	Bottom.	Surface.	Mid-depth.	Bottom.	
January, ...	123	89	118	37	30	30	Diatomaceæ. Infusoria. Rotifera.
February, ...	40	53	42	24	29	29	Diatomaceæ. Infusoria. Rotifera.
March, ...	186	115	73	43	45	43	Diatomaceæ. Infusoria. Rotifera.
April, ...	417	344	242	45	43	47	Diatomaceæ. Infusoria. Rotifera.
May, ...	647	467	495	40	37	41	Diatomaceæ. Infusoria. Rotifera.
June, ...	285	271	320	27	28	32	Diatomaceæ. Infusoria. Rotifera.
July, ...	168	161	141	22	27	29	Diatomaceæ. Chlorophyceæ. Cyanophyceæ.
August, ...	610	425	389	33	36	55	Diatomaceæ. Chlorophyceæ. Cyanophyceæ.
September, . . .	456	606	484	55	66	57	Diatomaceæ. Cyanophyceæ. Chlorophyceæ.
October, ...	407	476	390	39	42	40	Diatomaceæ. Infusoria. Cyanophyceæ. Crenothrix.
November, . . .	455	505	423	32	42	44	Diatomaceæ. Infusoria.
December, . . .	287	165	244	26	24	25	Diatomaceæ.
Mean, . . .	336	306	280	35	38	40	

TABLE No. 34 — *Continued.*

Whitehall Reservoir, 1901.

[Standard units per cubic centimeter.]

MONTHS.	ORGANISMS.	AMORPHOUS.	Principal Organisms.
	Surface.	Surface.	
January,	626	79	Infusoria. Rotifera.
February,	1,082	46	Infusoria. Rotifera.
March,	269	52	Infusoria. Rotifera.
April,	705	40	Infusoria. Rotifera.
May,	479	49	Diatomaceæ. Chlorophyceæ. Infusoria. Rotifera.
June,	641	48	Diatomaceæ. Chlorophyceæ. Infusoria. Rotifera.
July,	545	62	Diatomaceæ. Chlorophyceæ. Cyanophyceæ. Infusoria. Rotifera.
August,	725	40	Diatomaceæ. Chlorophyceæ. Cyanophyceæ. Infusoria. Rotifera.
September,	613	36	Diatomaceæ. Infusoria. Rotifera.
October,	484	28	Infusoria. Rotifera.
November,	2,071	34	Infusoria. Rotifera.
December,	217	25	Diatomaceæ.
Mean,	705	45	

Hopkinton Reservoir, 1901.

[Standard units per cubic centimeter.]

MONTHS.	ORGANISMS.				AMORPHOUS.				Principal Organisms in the Reservoir.
	Surface.	Mid-depth.	Bottom.	Inlet.	Surface.	Mid-depth.	Bottom.	Inlet.	
January,	178	222	111	14	30	32	41	26	Diatomaceæ. Infusoria.
February,	313	162	280	39	21	23	22	21	Diatomaceæ. Infusoria. Rotifera.
March,	36	43	80	34	45	52	61	39	Crenothrix.
April,	358	237	184	95	40	35	41	33	Diatomaceæ. Infusoria. Rotifera.
May,	957	865	475	61	36	37	41	24	Diatomaceæ. Infusoria.
June,	1,123	451	357	60	29	30	30	22	Diatomaceæ. Cyanophyceæ. Infusoria. Rotifera.
July,	692	364	114	23	27	30	28	19	Diatomaceæ. Chlorophyceæ. Cyanophyceæ.
August,	417	221	217	27	34	28	37	28	Chlorophyceæ. Cyanophyceæ.
September,	500	420	274	19	30	29	38	21	Chlorophyceæ. Cyanophyceæ. Infusoria. Rotifera.
October,	454	304	328	26	21	21	23	16	Cyanophyceæ. Infusoria.
November,	220	287	229	17	20	21	22	21	Cyanophyceæ. Infusoria.
December,	154	85	116	17	25	26	27	27	Cyanophyceæ. Infusoria. Rotifera.
Mean,	450	305	230	36	30	30	34	25	

TABLE No. 34 — *Continued.*

Ashland Reservoir, 1901.

[Standard units per cubic centimeter.]

MONTHS.	Organisms.				Amorphous.				Principal Organisms in the Reservoir.
	Surface.	Mid-depth.	Bottom.	Inlet.	Surface.	Mid-depth.	Bottom.	Inlet.	
January, . .	70	92	92	16	22	28	28	27	Diatomaceæ.
February, .	105	105	98	22	21	21	30	23	Diatomaceæ. Infusoria. Rotifera. Crenothrix.
March, . .	70	73	77	21	47	45	40	44	Diatomaceæ. Infusoria. Rotifera. Crenothrix.
April, . .	161	157	82	53	42	42	43	38	Diatomaceæ. Infusoria. Rotifera.
May, . .	257	155	44	59	33	36	40	35	Diatomaceæ. Infusoria. Rotifera.
June, . .	669	265	62	49	28	30	30	34	Diatomaceæ. Infusoria. Rotifera.
July, . .	226	71	40	28	20	19	23	35	Diatomaceæ. Chlorophyceæ. Cyanophyceæ. Infusoria. Rotifera.
August, . .	503	123	56	32	32	36	30	31	Diatomaceæ. Cyanophyceæ.
September, .	268	121	91	49	23	21	23	32	Diatomaceæ. Cyanophyceæ. Infusoria. Rotifera.
October, . .	256	220	158	26	18	17	16	17	Diatomaceæ. Cyanophyceæ.
November, .	242	181	196	16	23	22	20	20	Diatomaceæ. Cyanophyceæ.
December, .	104	146	169	46	25	22	22	24	Diatomaceæ. Cyanophyceæ.
Mean, .	244	144	97	35	28	28	29	30	

Framingham Reservoir No. 2, 1901.

[Standard units per cubic centimeter.]

MONTHS.	Organisms.				Amorphous.				Principal Organisms in the Reservoir.
	Surface.	Mid-depth.	Bottom.	Inlet.	Surface.	Mid-depth.	Bottom.	Inlet.	
January, . .	52	22	9	12	37	38	38	38	Infusoria.
February, .	54	13	12	54	22	21	21	23	Infusoria.
March, . .	29	18	30	85	53	43	42	58	Infusoria.
April, . .	118	94	64	140	36	33	37	34	Diatomaceæ. Infusoria.
May, . .	169	124	83	118	36	36	35	33	Diatomaceæ. Infusoria.
June, . .	285	135	108	70	21	29	30	41	Diatomaceæ. Cyanophyceæ. Infusoria. Rotifera.
July, . .	460	478	260	92	25	21	24	22	Chlorophyceæ. Cyanophyceæ.
August, . .	563	393	256	112	33	37	33	35	Chlorophyceæ. Cyanophyceæ.
September, .	261	142	162	171	60	92	86	69	Cyanophyceæ. Crenothrix.
October, . .	317	282	440	75	81	42	31	26	Cyanophyceæ. Infusoria. Crenothrix.
November, .	33	37	34	55	34	31	32	30	Diatomaceæ. Infusoria. Crenothrix.
December, .	31	52	25	65	24	24	22	25	Diatomaceæ.
Mean, .	198	149	124	87	34	37	36	36	

TABLE No. 34 — *Continued.*

Lake Cochituate, opposite Gate-house.

[Standard units per cubic centimeter.]

MONTHS.	ORGANISMS.			AMORPHOUS.			Principal Organisms.
	Surface.	Mid-depth.	Bottom.	Surface	Mid-depth.	Bottom.	
January, . . .	1,139	1,653	1,576	52	52	48	Diatomaceæ. Cyanophyceæ. Infusoria. Rotifera.
February, . . .	446	525	506	48	46	58	Diatomaceæ. Cyanophyceæ. Infusoria. Rotifera.
March, . . .	255	128	154	46	42	47	Diatomaceæ. Cyanophyceæ. Infusoria. Rotifera.
April, ...	574	659	403	45	50	55	Diatomaceæ. Cyanophyceæ. Infusoria. Rotifera.
May, ...	1,463	538	522	51	52	42	Diatomaceæ. Cyanophyceæ. Infusoria.
June, ...	1,913	348	304	46	38	75	Diatomaceæ. Cyanophyceæ. Infusoria.
July, ...	582	270	368	41	51	174	Cyanophyceæ.
August, . . .	861	392	648	43	50	306	Cyanophyceæ. Crenothrix.
September, . . .	1,146	249	434	49	72	364	Cyanophyceæ. Infusoria. Rotifera. Crenothrix.
October, . . .	441	457	351	38	42	237	Cyanophyceæ. Infusoria. Rotifera. Crenothrix.
November, . . .	1,508	1,451	1,097	34	36	46	Diatomaceæ. Cyanophyceæ. Infusoria. Rotifera. Crenothrix.
December, . . .	1,572	1,435	2,056	27	26	37	Diatomaceæ. Cyanophyceæ.
Mean, . . .	992	675	702	48	46	124	

Chestnut Hill Reservoir, 1901.

[Standard units per cubic centimeter.]

MONTHS.	ORGANISMS.					AMORPHOUS.					Principal Organisms in the Reservoir.
	Surface.	Mid depth.	Bottom.	Inlet (Sudbury Aqueduct).	Inlet (Cochituate Aqueduct).	Surface.	Mid-depth.	Bottom.	Inlet (Sudbury Aqueduct).	Inlet (Cochituate Aqueduct).	
January, .	-	-	-	126	899	-	-	-	43	42	- - -
February,	-	-	-	190	334	-	-	-	43	42	- - -
March, .	-	-	-	155	268	-	-	-	47	43	- - -
April, .	339	206	336	238	394	45	47	47	51	40	Diatomaceæ. Infusoria. Rotifera.
May, . .	405	451	398	594	669	44	52	46	46	39	Diatomaceæ. Infusoria. Rotifera.
June, .	299	266	239	420	1,138	37	36	36	48	52	Diatomaceæ. Chlorophyceæ. Infusoria. Rotifera.
July, . .	311	216	83	117	656	32	28	32	30	42	Diatomaceæ. Chlorophyceæ. Cyanophyceæ.
August, .	517	350	138	602	749	41	51	103	41	34	Diatomaceæ. Chlorophyceæ. Cyanophyceæ. Infusoria. Rotifera. Crenothrix.
September,	971	852	348	560	978	56	52	240	70	49	Diatomaceæ. Cyanophyceæ. Infusoria. Rotifera. Crenothrix.
October, .	512	440	612	362	656	37	42	64	39	32	Diatomaceæ. Chlorophyceæ. Cyanophyceæ. Infusoria. Rotifera. Crenothrix.
November,	572	516	409	554	928	43	43	36	43	36	Diatomaceæ. Cyanophyceæ. Infusoria. Rotifera. Crenothrix.
December,	-	-	-	212	-	-	-	-	24	-	- - -
Mean,	491	412	320	344	697	42	44	76	44	41	

TABLE No. 34 — *Continued.*

Outlet from Chestnut Hill Reservoir and Taps in Boston.

[Standard units per cubic centimeter.]

MONTHS.	ORGANISMS.			AMORPHOUS.		
	Effluent Gate-house No. 2, Chestnut Hill Reservoir.	Low-service Tap at No. 344 Boylston Street, Boston.	High-service Tap at No. 1 Ashburton Place, Boston.	Effluent Gate-house No. 2, Chestnut Hill Reservoir.	Low-service Tap at No. 344 Boylston Street, Boston.	High-service Tap at No. 1 Ashburton Place, Boston.
January,	402	252	307	44	41	41
February,	162	226	95	40	41	43
March,	146	72	79	46	43	39
April,	365	148	437	48	38	58
May,	522	365	448	38	48	44
June,	248	155	219	39	35	41
July,	277	156	114	31	27	28
August,	561	300	265	36	37	37
September,	920	379	433	50	54	58
October,	509	216	288	48	32	32
November,	451	280	349	34	36	53
December,	332	263	340	27	28	29
Mean,	413	243	280	39	38	42

TABLE No. 34 — *Concluded.*

Spot Pond and Fells Reservoir, 1901.

[Standard units per cubic centimeter.]

MONTHS.	ORGANISMS.				AMORPHOUS.				PRINCIPAL ORGANISMS.	
	SPOT POND.			FELLS RESERVOIR.	SPOT POND.			FELLS RESERVOIR.		
	Surface.	Mid-depth.	Bottom.	Effluent Gate-house.	Surface.	Mid-depth.	Bottom.	Effluent Gate-house.	Spot Pond.	Fells Reservoir.
January,	1,024	1,104	978	814	46	50	49	45	Diatomaceæ. Infusoria. Rotifera.	Diatomaceæ. Infusoria. Rotifera.
February,	814	907	585	509	49	47	46	46	Diatomaceæ. Infusoria. Rotifera.	Diatomaceæ. Infusoria. Rotifera.
March,	520	671	771	354	53	84	52	44	Diatomaceæ. Infusoria. Rotifera.	Diatomaceæ. Infusoria. Rotifera.
April,	1,096	869	829	751	47	47	53	52	Diatomaceæ. Infusoria.	Diatomaceæ. Infusoria. Rotifera.
May,	624	804	566	734	40	44	44	63	Diatomaceæ. Infusoria. Rotifera.	Diatomaceæ. Infusoria. Rotifera.
June,	416	361	337	340	38	38	41	34	Diatomaceæ. Cyanophyceæ. Infusoria. Rotifera.	Diatomaceæ. Infusoria. Rotifera.
July,	222	344	168	322	34	44	43	41	Diatomaceæ. Chlorophyceæ Cyanophyceæ. Infusoria. Rotifera.	Diatomaceæ. Chlorophyceæ. Infusoria. Rotifera.
August,	366	200	248	300	33	36	38	34	Diatomaceæ. Chlorophyceæ. Cyanophyceæ. Infusoria.	Diatomaceæ. Chlorophyceæ. Cyanophyceæ. Infusoria. Rotifera.
September,	284	190	107	175	41	42	62	35	Diatomaceæ. Cyanophyceæ. Infusoria. Rotifera.	Diatomaceæ. Infusoria. Rotifera.
October,	543	476	381	447	33	34	38	32	Diatomaceæ. Cyanophyceæ. Infusoria. Rotifera.	Diatomaceæ. Cyanophyceæ. Infusoria.
November,	1,066	926	940	1,063	37	34	39	36	Diatomaceæ. Cyanophyceæ. Infusoria.	Diatomaceæ. Cyanophyceæ. Infusoria.
December,	563	625	674	673	23	26	30	30	Diatomaceæ. Infusoria.	Diatomaceæ. Infusoria.
Mean,	628	623	549	540	40	44	45	41		

TABLE NO. 35. —*Bacterial Examinations of Water from Various Parts of the Metropolitan Water Works, 1901 (Means of Weekly Determinations).*

[Number of bacteria per cubic centimeter.]

MONTHS.	CHESTNUT HILL RESERVOIR.						Low-service Tap at No. 244 Boylston Street, Boston.	High-service Tap at No. 1 Ashburton Place, Boston.
	Surface.	Mid-depth.	Bottom.	Inlet (Sudbury Aqueduct).	Inlet (Cochituate Aqueduct).	Effluent Gate-house No. 2.		
January,	-	-	-	-	-	-	-	-
February,	-	-	-	70	53	61	66	73
March,	-	-	-	1,297	669	1,011	749	574
April,	186	195	221	303	81	203	105	185
May,	84	104	81	150	94	136	67	81
June,	26	24	32	32	45	28	79	104
July,	31	34	21	57	37	24	167	74
August,	25	28	28	103	289	48	74	122
September,	45	108	60	44	47	64	87	126
October,	97	72	38	33	52	63	102	149
November,	114	105	82	91	127	114	111	163
December,	-	-	-	203	-	110	170	198
Mean,	76	84	72	225	149	169	162	168

TABLE NO. 36. —*Examinations of Water from Brooks entering Reservoirs, 1901 (Means of Monthly Determinations).*

Brooks entering Lake Cochituate.

[Temperature in degrees Fahrenheit; turbidity by Silica standard; organisms and amorphous matter in standard units per cubic centimeter, bacteria in number per cubic centimeter, and color by platinum standard.]

	Temperature. (Degrees.)	Turbidity.	Organisms.	Amorphous.	Bacteria.
Beaver Dam Brook,	51.8	6.6	525	47	1,438
Beaver Dam Brook (last culvert),	53.7	6.1	287	49	2,459
Course Brook,	58.5	3.0	65	28	916
Dug Pond,	53.1	7.9	718	44	826
Circular dam at south end of lake,	53.7	4.3	239	38	980
Pegan Brook,	54.0	79.3	220	31	5,019
Snake Brook,	53.1	10.2	67	112	1,806

Brooks entering Sudbury Reservoir and Framingham Reservoir No. 3.

	Color.	Turbidity.	Organisms.	Amorphous.
Angelico Brook,	0.70	1.7	34	18
Brewer Brook,	0.55	2.3	31	18
Deerfoot Brook,	0.86	3.8	55	23
Rock Meadow Brook,	0.95	1.9	34	16
Mowry Brook,*	0.49	3.2	53	26
Broad Meadow Brook,	0.53	2.6	31	22

* Formerly called Brown Meadow Brook.

Table No. 37. — *Turbidity of Water from Various Parts of the Metropolitan Water Works, 1901 (Means of Weekly Determinations).*

[Silica standard.]

MONTHS.	Nashua River.	Sudbury Reservoir.				Framingham Reservoir No. 3.			Whitehall Reservoir.
	Surface.	Surface.	Mid-depth.	Bottom.	End of Open Channel.	Surface.	Mid-depth.	Bottom.	Surface.
January,	2.5	3.0	3.5	3.8	3.8	2.3	3.5	3.8	3.5
February,	2.8	2.0	2.3	3.0	2.6	2.5	2.8	2.8	1.9
March,	19.8	4.6	2.4	2.4	15.8	2.8	3.0	3.8	2.6
April,	9.3	3.0	3.5	3.5	2.6	3.3	4.0	4.0	1.9
May,	3.8	2.0	2.0	2.1	2.6	2.1	2.4	3.4	3.0
June,	4.0	2.5	3.0	3.0	2.8	2.0	2.0	2.3	2.1
July,	7.6	2.1	1.9	2.4	3.0	1.9	2.6	2.6	1.9
August,	3.5	1.9	1.9	2.0	2.5	1.9	2.1	2.8	2.1
September,	3.6	1.9	2.4	2.3	3.0	2.1	2.2	2.6	2.6
October,	3.5	1.9	2.0	2.2	3.8	2.2	2.2	2.4	2.4
November,	6.0	4.5	4.8	5.1	7.3	3.5	3.8	4.0	4.0
December,	8.3	3.5	3.8	4.0	3.3	3.8	4.0	4.3	3.0
Mean,	6.2	2.7	2.8	3.0	4.4	2.5	2.9	3.2	2.6

[Silica standard.]

MONTHS.	Hopkinton Reservoir.				Ashland Reservoir.				Framingham Reservoir No. 2.			
	Surface.	Mid-depth.	Bottom.	Inlet.	Surface.	Mid-depth.	Bottom.	Inlet.	Surface.	Mid-depth.	Bottom.	Inlet.
January,	2.5	2.5	5.5	2.0	2.0	2.0	2.8	2.0	2.0	2.0	2.0	2.8
February,	1.8	1.9	3.3	1.5	1.5	1.9	2.1	1.5	1.8	2.0	1.8	2.3
March,	2.1	2.4	3.6	4.1	2.4	2.6	2.9	5.8	6.6	6.1	6.1	3.8
April,	1.9	1.9	1.9	1.6	1.6	1.6	1.5	1.5	1.8	1.8	2.0	1.8
May,	1.7	2.1	2.0	1.6	1.6	1.8	1.7	1.5	1.6	2.0	2.3	2.3
June,	1.6	1.5	1.6	1.5	1.5	1.6	1.9	1.9	1.8	1.6	1.8	1.9
July,	1.4	1.6	1.8	1.5	1.4	1.5	1.7	1.6	1.7	1.7	1.8	1.6
August,	1.8	1.9	2.0	1.6	1.6	1.6	1.9	2.1	1.8	1.9	2.6	1.9
September,	1.9	1.9	3.1	1.8	1.8	1.8	1.9	1.8	2.4	2.6	2.9	2.5
October,	1.6	2.5	3.3	1.5	1.6	1.5	1.6	1.6	1.8	1.8	1.8	1.8
November,	3.0	3.3	3.5	2.8	2.1	2.1	2.1	2.1	1.9	2.0	2.8	2.0
December,	2.8	2.8	2.8	2.1	2.0	2.3	2.5	2.4	2.3	2.5	3.0	3.0
Mean,	2.0	2.2	2.9	2.0	1.8	1.9	2.1	2.2	2.3	2.3	2.5	2.3

TABLE No. 37 — *Concluded.*

[Silica standard.]

MONTHS.	FRAMINGHAM RESERVOIR No. 1.	LAKE COCHITUATE.			SPOT POND.			FELLS RESERVOIR.
	Surface.	Surface.	Mid-depth.	Bottom.	Surface.	Mid-depth.	Bottom.	Effluent Gate-house.
January,	2.0	2.5	2.8	3.0	3.8	5.0	4.8	4.5
February,	2.5	1.8	2.1	2.4	2.0	2.0	2.3	2.0
March,	6.6	2.4	2.5	5.7	5.5	3.0	2.0	2.9
April,	1.6	2.3	2.5	2.8	2.3	3.0	3.8	2.1
May,	1.8	2.3	2.4	2.8	2.8	4.3	5.2	3.2
June,	2.3	2.1	2.5	5.8	2.5	2.9	3.5	3.0
July,	3.6	1.9	1.9	16.8	2.0	2.6	3.5	3.7
August,	2.5	1.9	2.0	19.5	2.0	2.3	2.3	2.0
September,	3.5	2.1	2.3	15.3	2.5	3.0	4.3	2.0
October,	2.6	1.9	1.9	3.9	1.8	2.3	3.4	2.1
November,	4.0	3.0	3.8	5.3	3.0	3.5	4.3	3.4
December,	2.3	2.3	2.8	4.3	2.5	3.0	4.8	2.9
Mean,	2.9	2.2	2.5	7.3	2.7	3.1	3.7	2.8

[Silica standard.]

MONTHS.	CHESTNUT HILL RESERVOIR.						Tap at No. 244 Boylston Street, Boston.	Tap at No. 1 Ashburton Place, Boston.
	Surface.	Mid-depth.	Bottom.	Inlet (Sudbury Aqueduct).	Inlet (Cochituate Aqueduct).	Effluent Gate-house No. 2.		
January,	-	-	-	2.0	2.0	2.0	2.0	2.0
February,	-	-	-	2.4	1.6	1.8	1.6	1.5
March,	-	-	-	3.3	1.8	2.3	2.1	2.1
April,	2.3	2.7	3.0	2.8	1.6	2.5	1.9	3.3
May,	2.2	2.7	2.5	2.2	2.8	2.4	1.7	2.3
June,	2.5	2.5	2.8	2.5	1.8	2.8	1.8	3.1
July,	2.1	3.0	3.8	3.0	1.8	2.2	1.9	2.1
August,	1.8	2.8	10.6	2.9	2.6	2.9	2.0	2.3
September,	2.4	3.0	6.8	2.5	2.5	2.0	2.1	2.4
October,	2.0	2.2	3.7	2.6	1.9	2.1	1.9	2.0
November,	3.0	3.0	3.0	3.3	4.0	3.3	1.9	3.0
December,	-	-	-	2.5	-	2.3	2.5	2.5
Mean,	2.3	2.7	4.5	2.7	2.2	2.4	2.0	2.4

TABLE No. 38. — *Colors of Water from Various Parts of the Metropolitan Water Works, 1901 (Means of Weekly Determinations).*

[Platinum standard.]

MONTHS.	NASHUA RIVER.	SUDBURY RESERVOIR.				FRAMINGHAM RESERVOIR No. 3.			WHITEHALL RESERVOIR.
	Surface.	Surface.	Mid-depth.	Bottom.	End of Open Channel.	Surface.	Mid-depth.	Bottom.	Surface.
January,	0.39	0.43	0.47	0.47	0.37	0.49	0.48	0.49	0.63
February,	0.33	0.37	0.40	0.40	0.29	0.40	0.41	0.41	0.64
March,	0.56	0.35	0.34	0.38	0.52	0.35	0.35	0.36	0.63
April,	0.45	0.34	0.33	0.34	0.55	0.34	0.35	0.36	0.51
May,	0.55	0.37	0.36	0.36	0.64	0.37	0.38	0.38	0.59
June,	0.50	0.39	0.40	0.41	0.56	0.36	0.37	0.40	0.64
July,	0.48	0.31	0.34	0.35	0.46	0.28	0.31	0.35	0.60
August,	0.57	0.23	0.23	0.25	0.53	0.24	0.24	0.38	0.57
September,	0.48	0.24	0.25	0.26	0.48	0.25	0.25	0.28	0.52
October,	0.54	0.23	0.22	0.24	0.56	0.28	0.23	0.23	0.52
November,	0.44	0.24	0.25	0.27	0.44	0.24	0.24	0.24	0.60
December,	0.53	0.35	0.35	0.37	0.50	0.35	0.35	0.36	0.52
Mean,	0.49	0.32	0.33	0.34	0.49	0.33	0.33	0.35	0.58

[Platinum standard.]

MONTHS.	HOPKINTON RESERVOIR.				ASHLAND RESERVOIR.				FRAMINGHAM RESERVOIR No. 2.			
	Surface.	Mid-depth.	Bottom.	Inlet.	Surface.	Mid-depth.	Bottom.	Inlet.	Surface.	Mid-depth.	Bottom.	Inlet.
January,	0.60	0.61	0.67	1.03	0.58	0.59	0.64	1.05	0.77	0.84	0.86	0.69
February,	0.60	0.66	0.69	1.05	0.58	0.62	0.67	0.89	0.70	0.76	0.77	0.64
March,	0.53	0.56	0.61	0.87	0.58	0.59	0.60	0.75	0.64	0.64	0.65	0.64
April,	0.54	0.55	0.55	1.03	0.58	0.58	0.58	0.86	0.66	0.67	0.67	0.70
May,	0.70	0.68	0.68	1.54	0.74	0.73	0.69	1.46	0.93	0.93	0.92	1.00
June,	0.85	0.75	0.71	2.01	0.87	0.83	0.68	1.58	1.06	1.06	1.04	1.20
July,	0.77	0.68	0.62	2.26	0.78	0.75	0.64	1.70	0.96	0.97	0.99	1.20
August,	0.71	0.65	0.63	2.30	0.74	0.75	0.64	1.85	0.94	0.93	1.04	1.21
September,	0.73	0.68	0.71	2.28	0.77	0.76	0.66	2.33	1.10	1.09	1.07	1.24
October,	0.70	0.67	0.75	1.93	0.74	0.72	0.67	1.84	0.99	0.96	0.97	1.12
November,	0.69	0.64	0.66	1.34	0.71	0.71	0.71	1.26	0.92	0.91	0.91	0.80
December,	0.71	0.70	0.70	1.27	0.73	0.70	0.71	1.14	0.80	0.82	0.82	0.81
Mean,	0.68	0.65	0.67	1.57	0.70	0.69	0.66	1.39	0.87	0.88	0.89	0.94

TABLE No. 38 — *Concluded.*

[Platinum standard.]

MONTHS.	FRAMINGHAM RESERVOIR No. 1.	LAKE COCHITUATE.				SPOT POND.			FELLS RESERVOIR.
	Surface.	Surface.	Mid-depth.	Bottom.	Influent Streams.*	Surface.	Mid-depth.	Bottom.	Effluent Gate-house.
January,	0.86	0.30	0.31	0.33	0.62	0.17	0.19	0.19	0.24
February,	0.73	0.29	0.33	0.32	0.64	0.21	0.21	0.21	0.30
March,	0.61	0.28	0.31	0.56	0.73	0.21	0.23	0.22	0.31
April,	0.64	0.34	0.34	0.34	0.81	0.20	0.20	0.21	0.28
May,	0.86	0.38	0.33	0.36	1.04	0.17	0.18	0.21	0.22
June,	0.94	0.45	0.30	0.59	1.07	0.16	0.18	0.18	0.25
July,	0.81	0.35	0.28	1.00	1.10	0.09	0.13	0.16	0.15
August,	0.80	0.36	0.29	1.96	1.38	0.10	0.10	0.13	0.10
September,	0.92	0.33	0.30	2.23	1.36	0.11	0.12	0.15	0.11
October,	0.78	0.29	0.28	2.08	1.04	0.09	0.10	0.12	0.09
November,	0.90	0.33	0.34	0.72	0.90	0.11	0.11	0.12	0.10
December,	0.83	0.32	0.31	0.36	0.89	0.11	0.13	0.14	0.23
Mean,	0.81	0.33	0.31	0.90	0.97	0.14	0.16	0.17	0.20

* The colors given in this column represent the combined colors of the water of the four principal feeders. The color of each is determined monthly, and due weight is given, in combining the results, to the sizes of the streams.

[Platinum standard.]

MONTHS.	CHESTNUT HILL RESERVOIR.						Tap at No. 244 Boylston Street, Boston (Low-service).	Tap at No. 1 Ashburton Place, Boston (High-service).
	Surface.	Mid-depth.	Bottom.	Inlet (Sudbury Aqueduct).	Inlet (Cochituate Aqueduct).	Effluent Gate-house No. 2.		
January,	-	-	-	0.48	0.32	0.45	0.44	0.43
February,	-	-	-	0.45	0.32	0.41	0.41	0.41
March,	-	-	-	0.44	0.32	0.44	0.45	0.41
April,	0.33	0.33	0.34	0.35	0.28	0.31	0.30	0.33
May,	0.33	0.33	0.32	0.36	0.28	0.32	0.34	0.33
June,	0.39	0.39	0.36	0.42	0.42	0.39	0.40	0.43
July,	0.39	0.40	0.36	0.43	0.35	0.40	0.39	0.38
August,	0.29	0.28	0.62	0.29	0.34	0.28	0.29	0.31
September,	0.26	0.26	1.01	0.24	0.32	0.26	0.27	0.29
October,	0.24	0.25	0.35	0.22	0.26	0.24	0.24	0.25
November,	0.22	0.22	0.22	0.24	0.29	0.22	0.23	0.23
December,	-	-	-	0.32	-	0.28	0.30	0.27
Mean,	0.31	0.31	0.45	0.35	0.32	0.33	0.34	0.34

TABLE No. 39. — *Temperatures of Water from Various Parts of the Metropolitan Water Works, 1901 (Means of Weekly Determinations).*

[The temperatures are taken at the same places and times as the samples for microscopical examination; the depth given for each reservoir is the depth from high-water mark where the temperatures are taken.]

[Degrees Fahrenheit.]

MONTHS.	NASHUA RIVER.	SUDBURY RESERVOIR (DEPTH AT PLACE OF OBSERVATION 54.5 FEET).				FRAMINGHAM RESERVOIR NO. 3 (DEPTH AT PLACE OF OBSERVATION 20.5 FEET).			HOPKINTON RESERVOIR (DEPTH AT PLACE OF OBSERVATION 54.3 FEET).		
	Surface.	Surface.	Mid-depth.	Bottom.	End of Open Channel.	Surface.	Mid-depth.	Bottom.	Surface.	Mid-depth.	Bottom.
January, . .	32.6	34.6	37.2	38.7	32.6	33.8	35.6	36.5	35.8	37.2	38.7
February, . .	31.6	33.2	36.6	38.1	32.2	33.5	34.6	35.7	36.3	38.1	38.6
March, . . .	35.4	35.4	37.2	39.2	34.6	35.8	36.6	37.3	41.5	42.8	42.9
April, . . .	43.3	44.2	44.2	43.8	42.6	42.4	42.1	41.9	40.8	41.1	41.0
May, . . .	56.6	61.1	53.0	51.1	54.7	56.0	54.7	53.5	55.8	48.3	46.9
June, . . .	67.5	68.1	62.6	61.1	68.1	68.7	66.8	64.6	64.2	53.9	50.8
July, . . .	77.5	78.7	71.2	68.1	76.9	77.7	74.8	71.0	75.7	59.8	52.5
August, . .	73.8	74.9	74.0	73.2	72.2	75.5	74.6	73.1	75.3	53.4	49.7
September, . .	69.8	70.1	69.8	69.1	67.6	69.7	70.4	70.6	70.2	52.7	49.6
October, . .	57.0	58.9	58.5	57.8	56.8	57.8	58.2	58.5	57.4	53.4	51.7
November, . .	39.0	42.5	42.8	42.3	38.5	42.1	42.6	42.9	43.8	44.3	44.8
December, . .	33.1	33.8	34.5	34.9	32.9	33.9	34.5	34.8	36.5	36.9	37.3
Mean, . .	51.4	53.0	51.8	51.4	50.8	52.2	52.1	51.7	52.8	46.7	45.4

[Degrees Fahrenheit.]

MONTHS.	ASHLAND RESERVOIR (DEPTH AT PLACE OF OBSERVATION 40.7 FEET).			FRAMINGHAM RESERVOIR NO. 2 (DEPTH AT PLACE OF OBSERVATION 20.5 FEET).			LAKE COCHITUATE (DEPTH AT PLACE OF OBSERVATION 62.0 FEET).			WHITEHALL RESERVOIR.
	Surface.	Mid-depth.	Bottom.	Surface.	Mid-depth.	Bottom.	Surface.	Mid-depth.	Bottom.	Surface.
January, .	35.1	38.1	40.0	33.9	35.6	36.8	37.5	38.0	38.7	36.6
February, .	34.7	38.7	40.4	33.0	34.6	36.0	36.0	37.6	39.0	33.6
March, . .	39.5	40.4	40.7	35.7	36.4	37.2	37.0	38.2	39.5	37.8
April, . .	41.7	41.3	41.3	42.8	42.5	42.0	42.0	41.4	41.0	43.9
May, . .	53.7	50.7	47.9	56.6	55.2	54.3	54.0	46.5	43.7	55.4
June, . .	67.7	56.5	48.7	71.2	68.3	65.5	67.7	46.5	43.8	66.8
July, . .	80.1	58.4	48.6	78.8	75.4	71.7	78.3	48.4	46.2	78.2
August, .	75.0	59.3	49.8	75.3	74.5	73.2	75.4	49.0	47.0	74.8
September, .	69.9	60.6	48.5	69.3	69.7	69.5	70.7	47.1	44.3	69.1
October, .	56.3	54.3	47.2	57.5	57.9	58.2	58.0	48.0	44.4	57.3
November, .	42.1	43.4	44.5	40.5	41.0	41.4	42.8	42.6	43.3	37.0
December, .	38.0	37.5	37.5	33.7	34.4	34.8	35.9	36.9	36.6	34.0
Mean, .	52.8	48.3	44.6	52.4	52.1	51.7	52.9	43.4	42.3	52.0

Table No. 39 — *Concluded.*

[Degrees Fahrenheit.]

Months.	Spot Pond (Depth at Place of Observation 28.0 Feet).			Chestnut Hill Reservoir (Depth at Place of Observation 26.0 Feet).						Tap at No. 244, Boylston Street, Boston.	Tap at No. 1, Ashburton Place, Boston.
	Surface.	Mid-depth.	Bottom.	Surface.	Mid-depth.	Bottom.	Inlet (Sudbury Aqueduct).	Inlet (Cochituate Aqueduct).	Effluent Gate-house No. 2.		
January, . . .	36.0	37.1	37.8	-	-	-	37.1	37.5	36.1	37.1	39.2
February, . . .	37.0	38.3	38.6	-	-	-	36.7	38.4	35.3	36.5	38.1
March, . . .	37.8	39.0	39.5	-	-	-	38.3	39.1	37.8	38.9	39.4
April, . . .	41.3	41.5	41.5	40.9	41.9	42.3	42.6	42.7	43.0	44.4	44.1
May, ...	53.3	52.1	50.1	53.9	51.8	48.1	53.2	48.2	53.3	53.4	54.1
June, ...	64.4	63.4	61.5	64.3	61.3	48.6	61.7	63.1	64.0	63.0	63.6
July, ...	76.2	71.2	61.0	72.9	67.7	48.8	70.3	72.0	73.7	73.4	73.8
August, . . .	74.8	75.0	62.6	75.7	72.3	54.9	74.3	74.4	74.4	73.5	74.9
September, . .	71.1	71.4	64.3	70.5	71.6	54.5	71.4	71.4	71.3	71.3	71.8
October, . . .	59.0	59.4	59.3	59.9	57.9	55.2	57.9	57.9	60.0	60.8	60.7
November, . .	44.6	45.1	45.3	46.8	45.6	45.6	45.1	48.3	45.4	47.5	48.4
December, . . .	33.3	34.1	34.2	-	-	-	35.6	-	35.6	38.5	38.8
Mean, . . .	52.4	52.3	49.6	60.6	58.8	49.8	52.0	53.9	52.5	53.2	53.9

Table No. 40. — *Temperatures of the Air at Three Stations on the Metropolitan Water Works, 1901.*

[Degrees Fahrenheit.]

MONTHS.	Chestnut Hill Reservoir.			Framingham.			Clinton.		
	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.
January, ...	48.0	—6.0	25.8	48.0	—7.0	25.8	47.0	—7.0	24.2
February, . . .	45.5	5.0	22.4	44.0	6.0	22.3	38.5	5.5	20.9
March, ...	58.0	5.0	35.9	53.0	3.0	35.2	53.5	4.5	32.8
April, ...	80.0	30.5	44.0	82.0	31.0	45.5	82.0	29.0	43.9
May, ...	86.0	30.0	54.9	86.0	34.0	56.5	85.0	35.0	55.4
June, ...	99.0	42.0	68.2	98.0	44.0	68.9	95.0	41.0	68.0
July, ...	97.0	52.0	75.0	99.0	51.0	74.5	98.0	48.0	73.0
August, ...	90.5	54.0	72.0	87.0	52.0	71.2	85.0	53.5	70.0
September, . . .	90.0	38.0	65.2	89.0	36.0	64.5	85.5	32.5	62.9
October, ...	75.5	28.5	53.4	75.0	27.0	52.6	75.0	24.5	51.0
November, . . .	65.0	8.0	35.6	64.0	8.0	35.4	68.5	8.0	34.0
December, . . .	63.5	0.0	30.7	61.0	—5.0	28.5	60.0	—10.5	26.0
Averages, . . .	-	-	48.6	-	-	48.4	-	-	46.8

TABLE NO. 41. — *Table showing Length of Main Lines of Pipes and Connections owned and operated by Metropolitan Water and Sewerage Board and Number of Valves set in Same.*

	DIAMETER OF PIPES IN INCHES.													Totals.
	60	48	42	36	30	24	20	16	14	12	10	8	6	
Length owned and operated January 1, 1901 (feet),	307	124,125	8,075	46,496	26,839	40,930	51,509	54,379	26	13,874	489	1,389	740	368,678
Gate valves in same,	-	33	-	37	27	33	29	44	1	43	5	4	12	268
Air valves in same,	-	67	3	33	4	13	30	27	-	4	-	-	-	181
Length laid or relaid during 1901 (feet),	-	39	-	19	68	6,212	6,764	99	-	1,735	41	-	-	14,977
Gate valves in same,	-	-	-	-	-	1	4	4	-	4	2	-	-	15
Air valves in same,	-	-	-	-	-	7	5	1	-	-	-	-	-	13
Length abandoned during 1901 (feet),	-	1	-	3	-	538	1,492	494	-	958	-	-	-	3,486
Gate valves in same,	-	-	-	-	-	1	-	1	-	1	-	-	-	3
Air valves in same,	-	-	-	-	-	1	1	-	-	-	-	-	-	2
Total length owned and operated January 1, 1902 (feet),	307	124,163	8,075	46,512	26,907	46,604	56,781	53,984	26	14,151	530	1,389	740	380,169*
Gate valves in same,	-	33	-	37	27	33	33	47	1	46	7	4	12	280
Air valves in same,	-	67	3	33	4	19	34	28	-	4	-	-	-	192

* 72 miles.

TABLE NO. 42. — *Statement of Cast-iron Hydrant, Blow-off and Drain Pipes laid to January 1, 1902, owned and operated by Metropolitan Water and Sewerage Board.*

	DIAMETER OF PIPES IN INCHES.							Totals.
	24	16	12	10	8	6	4	
Length laid to January 1, 1901 (feet),	352	2,110	3,162	-	98	2,109	981	8,812
Length laid during 1901 (feet),	-	-	334	107	155	500	32	1,128
Length abandoned during 1901 (feet),	-	-	6	-	160	5	34	205
Total length in use January 1, 1902 (feet),	352	2,110	3,490	107	93	2,604	979	9,735
Valves set to January 1, 1901,	-	16	57	-	-	44	35	152
Valves set during 1901,	-	-	-	1	1	9	1	12
Valves abandoned during 1901,	-	-	-	-	1	-	2	3
Total valves in use January 1, 1902,	-	16	57	1	-	53	34	161

TABLE No. 43. — *Length of Water Pipes, Four Inches in Diameter and Larger, in the Several Cities and Towns supplied by the Metropolitan Water Works.*

BY WHOM OWNED.	INCHES.																			TOTAL.	
	60	48	42	40	36	30	28	24	20	18	16	14	12	10	8	7	6	5	4	Feet.	Miles.
Metropolitan Water Works.	307	124,163	8,075	-	46,512	26,907	-	46,604	56,781	-	53,984	26	14,151	530	1,389	-	740	-	-	380,169	72.00
Boston, . . .	-	33,671	16,813	23,104	89,986	84,237	244	79,832	93,813	-	179,273	-	1,106,375	96,955	541,408	-	1,393,580	-	95,407	3,784,698	716.80
Somerville, . .	-	-	-	-	-	-	-	-	3,596	387	2,071	8,037	72,027	42,921	89,148	-	190,202	-	21,158	429,547	81.35
Malden, . . .	-	-	-	-	-	-	-	-	-	-	-	12,174	62,567	20,511	64,676	-	185,108	-	84,892	429,928	81.42
Chelsea, . . .	-	-	-	-	-	-	-	-	-	-	2,380	-	-	38,001	24,759	-	125,414	-	12,035	202,589	38.37
Quincy, . . .	-	-	-	-	-	-	-	-	2,679	-	19,813	-	21,230	28,384	77,435	994	182,875	948	88,085	422,443	80.01
Everett, . . .	-	-	-	-	-	-	-	2,484	2,900	-	2,233	206	5,570	32,847	19,840	-	115,924	-	36,047	218,051	41.30
Medford, . .	-	-	-	-	-	-	-	-	1,972	-	6,775	9,585	23,482	27,842	64,051	-	81,474	-	58,800	273,481	51.80
Melrose, . . .	-	-	-	-	-	-	-	-	-	-	5,200	2,920	14,586	5,022	16,314	-	97,981	-	90,513	232,536	44.04
Revere,* . . .	-	-	-	-	-	-	-	-	-	-	24,000	4,450	7,300	7,950	15,565	-	60,060	-	66,195	185,520	35.14
Watertown, . .	-	-	-	-	-	-	-	-	-	-	400	12,127	5,959	4,169	18,861	-	103,723	-	13,239	158,478	30.01
Winthrop,* . .	-	-	-	-	-	-	-	-	-	-	-	-	4,000	5,000	19,176	-	20,284	-	74,836	123,296	23.35
Belmont, . .	-	-	-	-	-	-	-	-	-	-	-	-	2,161	11,102	12,896	-	67,258	-	283	93,700	17.75
Nahant, . . .	-	-	-	-	-	-	-	-	-	-	-	-	-	11,550	-	-	28,840	-	38,125	78,515	14.87
Arlington, . .	-	-	-	-	-	-	-	-	-	-	-	-	31,618	21,106	22,502	-	68,847	-	32,509	176,582	33.44
Swampscott, . .	-	-	-	-	-	-	-	-	-	-	-	-	9,472	12,247	16,694	-	42,868	-	11,558	92,834	17.58
Stoneham, . .	-	-	-	-	-	-	-	-	-	-	-	-	4,500	3,800	2,800	-	70,000	-	10,000	91,100	17.25
Total feet, .	307	157,834	24,888	23,104	86,498	111,144	244	128,920	161,741	387	296,129	49,525	1,384,998	369,937	1,007,514	994	2,835,173	948	733,182	7,373,467	-
Total miles, .	.06	29.89	4.71	4.38	16.38	21.05	.05	24.42	30.63	.07	56.09	9.38	262.31	70.06	190.82	.19	536.96	.18	138.86	-	1,396.49

* Pipes owned by Revere Water Company.

TABLE NO. 42. — *Statement of Cast-iron Hydrant, Blow-off and Drain Pipes laid to January 1, 1902, owned and operated by Metropolitan Water and Sewerage Board.*

	DIAMETER OF PIPES IN INCHES.							Totals.
	24	16	12	10	8	6	4	
Length laid to January 1, 1901 (feet),	352	2,110	3,162	-	98	2,109	981	8,812
Length laid during 1901 (feet),	-	-	334	107	155	500	32	1,128
Length abandoned during 1901 (feet),	-	-	6	-	160	5	34	205
Total length in use January 1, 1902 (feet),	352	2,110	3,490	107	93	2,604	979	9,735
Valves set to January 1, 1901,	-	16	57	-	-	44	35	152
Valves set during 1901,	-	-	-	1	1	9	1	12
Valves abandoned during 1901,	-	-	-	-	1	-	2	3
Total valves in use January 1, 1902,	-	16	57	1	-	53	34	161

TABLE No. 43. — *Length of Water Pipes, Four Inches in Diameter and Larger, in the Several Cities and Towns supplied by the Metropolitan Water Works.*

BY WHOM OWNED.	INCHES.																			TOTAL.	
	60	48	42	40	36	30	28	24	20	18	16	14	12	10	8	7	6	5	4	Feet.	Miles.
Metropolitan Water Works.	307	124,163	8,075	-	46,512	26,907	-	46,604	56,781	-	53,984	26	14,151	530	1,389	-	740	-	-	380,169	72.00
Boston, . . .	-	33,671	16,813	23,104	39,986	84,237	244	79,832	93,813	-	179,273	-	1,106,375	96,955	541,408	-	1,393,580	-	95,407	3,784,698	716.80
Somerville, . .	-	-	-	-	-	-	-	-	3,596	387	2,071	8,037	72,027	42,921	89,148	-	190,202	-	21,158	429,547	81.35
Malden, . . .	-	-	-	-	-	-	-	-	-	-	-	12,174	62,567	20,511	64,676	-	185,108	-	84,892	429,928	81.42
Chelsea, . . .	-	-	-	-	-	-	-	-	-	-	2,380	-	-	38,001	24,759	-	125,414	-	12,035	202,589	38.37
Quincy, . . .	-	-	-	-	-	-	-	-	2,679	-	19,813	-	21,230	28,384	77,435	994	182,875	948	88,085	422,443	80.01
Everett, . . .	-	-	-	-	-	-	-	2,484	2,900	-	2,233	206	5,570	32,847	19,840	-	115,924	-	36,047	218,051	41.30
Medford, . .	-	-	-	-	-	-	-	-	1,972	-	6,775	9,585	23,482	27,842	64,051	-	81,474	-	58,300	273,481	51.80
Melrose, . . .	-	-	-	-	-	-	-	-	-	-	5,200	2,920	14,586	5,022	16,314	-	97,981	-	90,513	232,536	44.04
Revere,* . . .	-	-	-	-	-	-	-	-	-	-	24,000	4,450	7,300	7,950	15,565	-	60,060	-	66,195	185,520	35.14
Watertown, . .	-	-	-	-	-	-	-	-	-	-	400	12,127	5,959	4,169	18,861	-	108,723	-	13,239	158,478	30.01
Winthrop,* . .	-	-	-	-	-	-	-	-	-	-	-	-	4,000	5,000	19,176	-	20,284	-	74,836	123,296	23.35
Belmont, . .	-	-	-	-	-	-	-	-	-	-	-	-	2,161	11,102	12,896	-	67,258	-	283	93,700	17.75
Nahant, . . .	-	-	-	-	-	-	-	-	-	-	-	-	-	11,550	-	-	28,840	-	38,125	78,515	14.87
Arlington, . .	-	-	-	-	-	-	-	-	-	-	-	-	31,618	21,106	22,502	-	68,847	-	32,509	176,582	33.44
Swampscott, . .	-	-	-	-	-	-	-	-	-	-	-	-	9,472	12,247	16,694	-	42,863	-	11,558	92,834	17.58
Stoneham, . .	-	-	-	-	-	-	-	-	-	-	-	-	4,500	3,800	2,800	-	70,000	-	10,000	91,100	17.25
Total feet, .	307	157,834	24,888	23,104	86,498	111,144	244	128,920	161,741	387	296,129	49,525	1,384,998	369,937	1,007,514	994	2,835,173	948	733,182	7,373,467	-
Total miles, .	.06	29.89	4.71	4.38	16.38	21.05	.05	24.42	30.63	.07	56.09	9.38	262.31	70.06	190.82	.19	536.96	.18	138.86	-	1,396.49

* Pipes owned by Revere Water Company.

TABLE No. 44. — *Number of Service Pipes, Meters and Fire Hydrants in the Several Cities and Towns supplied by the Metropolitan Water Works.*

CITY OR TOWN.	Services.	Meters.	Fire Hydrants.
Boston,	88,647	4,473	7,700
Somerville,	10,520	224	927
Malden,	6,604	3,633	400
Chelsea,	6,198	113	263
Quincy,	4,480	147	576
Everett,	4,541	44	468
Medford,	3,967	114	460
Melrose,	3,177	82	266
Revere,	2,220	19	126
Watertown,	1,651	1,475	272
Winthrop,	1,663	4	104
Belmont,	599	599	140
Nahant,	446	16	57
Arlington,	1,675	78	333
Swampscott,	1,004	-	117
Stoneham,	1,148	14	70
Totals,	138,540	11,030	12,279

APPENDIX No. 4.

REPORT UPON OFFICIAL TESTS OF FOUR NEW PUMPING ENGINES AT THE CHESTNUT HILL LOW-SERVICE AND SPOT POND PUMPING STATIONS, MADE BY DEXTER BRACKETT, ENGINEER OF DISTRIBUTION DEPARTMENT, AND W. J. SANDO, M.E., REPRESENTING THE HOLLY MANUFACTURING COMPANY.

The official test of the three engines at the low-service station at Chestnut Hill was made on April 30 and May 1, and of the engine at Spot Pond on June 4 and 5.

Description of Pumping Plants.

The engines were designed and built by the Holly Manufacturing Company of Lockport, N. Y. They are all of the vertical triple expansion self-contained type, with pump plungers directly under the steam cylinders and rigidly connected with the steam pistons. The pumps are of a new design, each engine having three single acting outside packed plungers, and six suction and six delivery valve chambers.

The engines at the Chestnut Hill station are all made from the same patterns, and the Spot Pond engine is of the same general design, with larger steam cylinders and smaller pump plungers. The Chestnut Hill engines have each a capacity of 35,000,000 U. S. gallons in 24 hours against a head of 60 feet, and the Spot Pond engine has a capacity of 20,000,000 U. S. gallons against a head of 125 feet. All the engines have a stroke of 60 inches, those at Chestnut Hill being designed to make 30 revolutions and the engines at Spot Pond 25 revolutions per minute.

On the engines at the Chestnut Hill station the steam inlet and exhaust valves for the high and intermediate-pressure cylinders, and the inlet valves of the low-pressure cylinders, are of the Corliss type; the exhaust valves for the low-pressure cylinders are of the poppet type. At Spot Pond the exhaust valves for the intermediate-pressure cylinder and the inlet valves for the low-pressure cylinder are also of the poppet type. All valves receive their motion from a lay shaft which is driven from the crank shaft by means of bevelled gears. The cut-off on the high-pressure cylinder of each engine is controlled by an automatic centrifugal governor, and is also adjustable by hand. On the Chestnut Hill engines the cut-offs on both the intermediate and low-pressure cylinders are adjustable by hand. On the Spot Pond engine the cut-off on the intermediate-pressure cylinder can be so adjusted.

The cylinders are jacketed on barrels and heads. All valves are placed in the cylinder heads. There are receivers fitted with copper reheating coils between the high and intermediate-pressure cylinders and between the intermediate and low-pressure cylinders. The volumes are respectively 6¾ times and 2¾ times the volumes of the preceding cylinders.

The system of steam distribution through the jackets and receiver coils is as follows: The high-pressure jacket is supplied with steam from the main steam pipe at the same pressure as the steam at the throttle valve. The first receiver coil is supplied from the high-pressure jacket outlet, and the intermediate-pressure jacket is supplied at a reduced pressure from the first receiver coil outlet. The second receiver coil is supplied from the outlet of the intermediate-pressure jacket, and the low-pressure jacket from the outlet of the second receiver coil at a reduced pressure. The low-pressure jacket drain is trapped and discharged into the working side of the second receiver, and is then trapped to waste. The condensed water from the first and second receiver coils is discharged through ¼ inch pipes into the intermediate and low-pressure jackets. Each surface condenser at the Chestnut Hill station contains 725 square feet of cooling surface, and that at the Spot Pond station 785 square feet. The circulating water is taken from and returned to the suction main. Directly on top of each condenser there is an exhaust heater which contains 150 square feet of heating surface. The boiler feed pumps are attached to and driven by the main engines. An air compressor for charging the discharge air chambers is attached to and driven by each of the engines.

The engine bed-plates are supported upon the valve chamber castings, and also upon cast-iron columns. Each engine has two suction and two discharge pipes, and six valve chambers, three of which are located on either side of the centre line of the plunger chambers to which they are connected. The valve chambers are also connected longitudinally by the suction main at the bottom and the discharge main near the top. The valves are of rubber, $4\frac{3}{16}$ inches in diameter, and the area of the water way through each set of suction and discharge valves is 200 per cent. of the area of the pump plungers.

Steam at both stations is furnished by vertical fire-tube boilers designed by Dean & Main, M.E. At the Chestnut Hill station each boiler is 98 inches in diameter, 25 feet high, and contains 384 2-inch tubes 15 feet in length. At Spot Pond each boiler is 92 inches in diameter, 25 feet high, and contains 256 2¼-inch tubes 15 feet in length. At both stations the feed water, before entering the boilers, passes through a Green fuel economizer containing 144 tubes $4\frac{9}{16}$ inches in diameter and 9 feet long, around which the escaping gases from the boilers pass on the way to the chimney. The boilers at the Chestnut Hill station were built by the Atlantic Works of East Boston, and those at Spot Pond by the Lake Erie Boiler Works of Buffalo, N. Y.

Method of Conducting Trials.

The contracts provided that the engines should fulfil the following requirements: —

	Chestnut Hill Engines.	Spot Pond Engine.
Maximum plunger speed (feet per minute),	300	250
Capacity at maximum speed (U. S. gallons per 24 hours),	35,000,000	20,000,000
Duty in foot-pounds per 1,000 pounds commercially dry steam,	145,000,000	150,000,000
Head to be pumped against (feet),	45	125
Steam pressure at throttle valve (pounds per square inch),	150	150

The contracts also provided that the trials should be of 24 hours' duration; that the capacity of the engines should be determined by weir measurement, or some other method satisfactory to the conductors of the trials; that steam containing less than 1½ per cent. of entrained water, as determined by calorimeter measurement, should be considered as dry steam; and that in computing the duty the work performed by the engines should be based upon the displacement of the pump plungers.

The contract requirement for duty at both stations was based upon the quantity of steam used by the engines, and for this reason great care was taken to accurately determine the quantity used. At the Chestnut Hill station all of the boilers were used to supply steam to the engines, so that there was no question regarding leakage between the boilers. At the Spot Pond station a blank flange was placed in the connection between the boilers used during the trial and the remaining boiler, which was used to supply steam for the electric light engine and other purposes. At both stations all pipes from which there was a possibility of leakage were either closed by blank flanges or disconnected, so that any leakage could be discovered and measured. At the Chestnut Hill station a leakage test of the boilers and steam piping could not be made, on account of the necessity of continuously operating the machinery; but at the Spot Pond station a blank flange was placed in the main steam pipe near the engine, and a pressure of 150 pounds was maintained on the boilers, economizer and piping for 24 hours. At the end of that time a sufficient quantity of water was weighed and pumped into the boilers to bring the water level to the same elevation as it was at the beginning of the test, and it was found that the leakage was at the rate of 36 pounds per hour. At the

Chestnut Hill station the quantity of steam used by any one of the engines, as determined by the water fed to the boilers, could not be measured, because all the engines are supplied with steam from one main line of steam pipe, and it was absolutely necessary that at least two of the engines should be continually operated in order to maintain the supply of water to the Metropolitan District. For this reason all of the engines at this station were tested together.

The quantity of steam used by each engine was determined in the following manner: The condensed steam from the low-pressure cylinder was discharged by the air pump into a wrought-iron tank, from which it was drawn into a weighing tank. Another wrought-iron tank, resting on a platform scale, received the condensed steam from the low-pressure jacket. A wrought-iron tank received the condensed steam from the separators on all of the engines. The water from all of these tanks, after being carefully weighed, was discharged into a suction tank, from which it was forced into the boilers by the feed pumps attached to the engines. The supply to the boilers was regulated by means of a by-pass, through which the discharge from the feed pumps could be returned to the suction tank.

During the trial at the Chestnut Hill station the electric light and economizer engines were not operated, the light for the building being supplied from the plant at the high-service station. At the Spot Pond station steam for operating the lighting engine was supplied from a separate boiler, which was disconnected from the boilers supplying steam to the engine tested.

At both stations the steam pressure at the engine was determined by a mercurial gage connected at the engine throttle valve. The vacuum in the condenser was also determined by a mercurial gage, and readings of both steam and vacuum gages were taken every 20 minutes of the trial at the Chestnut Hill station, and every 15 minutes at the Spot Pond station. The elevation of the water in each of the pump wells was determined from readings of float gages taken every 15 minutes during the test. The pressure of water in the force mains was determined from the average of readings taken every 5 minutes on the mercurial gages connected with the force mains of each engine. The revolutions of the engines were observed every 20 minutes at Chestnut Hill and every 15 minutes at Spot Pond.

The condensed steam discharged by each of the air pumps was weighed every 20 minutes at Chestnut Hill and every 15 minutes at Spot Pond. The condensed steam from the low-pressure jacket drains was weighed every 60 minutes at Chestnut Hill and every 30 minutes at Spot Pond. The discharge from the separator drains was weighed each hour at both stations. Observations were made and recorded each hour during the trial at each station of the steam pressure in the receivers between the steam cylinders; the temperature of steam at the throttle valve at the inlet of each steam cylinder and at the low-pressure exhaust of all the engines;

the temperatures of water in the drains from the low-pressure jackets; temperatures of water discharged from the air pumps, of water entering and leaving the condensers, of water in the several weighing tanks and of air in the engine and boiler rooms. In the boiler room records were made of the weight of coal fed to each boiler during every hour. The level of the water in each boiler, the steam pressures in the boilers, the amount of draft, the temperature of the feed water and of the flue gases entering and leaving the economizer, and the counter of the water meter on the boiler feed pipe were observed and recorded each hour. A sample of the flue gases was taken and analyzed each hour during both trials.

At both stations the condition of the fires at the beginning and end of the tests was as nearly the same as could be determined by the careful inspection of three persons, and the recorded weight very closely represents the actual quantity burned during the 24 hours.

All scales for weighing water and coal were tested and sealed immediately before each trial. All indicator springs were tested and calibrated immediately after each trial, and all pump valves were examined and tested for leakage and found to be practically tight.

Indicator diagrams from all the steam cylinders were taken every hour. The indicators on all the steam cylinders of each engine were electrically connected in such manner that six diagrams were taken simultaneously from each engine, each of which represented the average pressure in the cylinder for 1 minute. The pencil friction of the indicator was prevented by a current breaker which gave the pencil an intermittent instead of a constant contact with the paper, and formed the diagram by a series of dots. At the Chestnut Hill station the pencil made 30 revolutions on each diagram and at the Spot Pond station 25 revolutions, so that each diagram represents the average pressure in the cylinder for 1 minute.

While the indicator diagrams were being taken, 5-second observations were made of the pressure in the force mains, and from these observations the actual horse-power of work done by each engine while the diagrams were being made was determined.

The average friction of each engine for the 24 hours of the trial was determined from the average of the differences between indicated horse-power and the actual horse-power of work done during times while the diagrams were being taken.

Calorimeter measurements of the quality of the steam were made during both trials.

The coal used at the Chestnut Hill station was the Loyal Hanna Sonman Shaft coal, and at the Spot Pond station Georges Creek Cumberland coal, — in both cases the coal in regular use at the stations. The number of thermal units per pound of coal was not actually determined, and the quantities used in the report are those determined for the same kind of coal on previous tests.

In connection with the test of the engine at the Spot Pond station a careful weir measurement was made of the water pumped. The water pumped by the engine was forced through a 36-inch pipe to a distributing reservoir, where it was delivered into a masonry chamber 20.5 feet long, 6 feet wide and 18.25 feet deep. The water entered the side of the chamber at the bottom near one end, passed through a screen, and then, after flowing 13 feet through the chamber, passed over a weir 5.991 feet long, having a brass edge 0.25 of an inch wide, finished perfectly level. A temporary floor was placed in the chamber between the screen and the weir, making the channel approaching the weir 6 feet in depth. A rectangular brass plate, 8 inches long by 6 inches high, with a hole $1\frac{1}{16}$ inches in diameter in the centre, was set flush with the side of the channel, with centre of the hole 6 feet back from the weir and .790 of a foot below the crest. The hole in the center of the plate was connected by a 1-inch pipe with a can in which the water level was observed every 2 minutes during the entire 24 hours. The quantity delivered was determined by three different formulæ, and the average result used. The leakage from the force main was tested before the trial.

At the Chestnut Hill station no measurement of the slip of the pumps was made during the trial, but the monthly records of water pumped at the station compared with careful current meter measurements of the water delivered to the pumps show that the slip does not exceed 1¼ per cent.

Principal Dimensions of Engines.

		Low-service Engines.			Northern High-service Engine Number 9.
		Number 5.	Number 6.	Number 7.	
1	Diameter H. P. cylinder (nominal) (inches),	17	17	17	22
2	Diameter I. P. cylinder (nominal) (inches), .	31.25	31.25	31.25	41.5
3	Diameter L. P. cylinder (nominal) (inches),	48	48	48	62
	Cylinder Clearances.				
4	High pressure (per cent), ...	-	1.5	-	1
5	Intermediate pressure, (per cent.), . . .	-	1.3	-	.5
6	Low pressure (per cent.), ...	-	1.1	-	.5
7	Diameter of plungers (nominal) (inches), .	37	37	37	30.5
8	Stroke of pistons and plungers (nominal) (inches).	60	60	60	60
9	Diameter of suction and discharge pipes (inches).	36	36	36	30
10	Diameter of fly wheels (2) (feet), . . .	17	17	17	17
11	Weight of each wheel (pounds), . . .	30,000	30,000	30,000	34,000
12	Revolutions per minute for capacity, . .	29.01	29.01	29.01	24.4
13	Speed per minute (feet), ...	290.1	290.1	290.1	244.0

Principal Dimensions of Boiler Plant.

		Low-service Pumping Station (3 Boilers).	Northern High-service Pumping Station.
14	Number of boilers used during test,	3	2
15	Boiler diameter (feet),	8.17	7.67
16	Boiler length (over all) (feet),	29.5	29.37
17	Number of tubes in each boiler,	384	256
18	Diameter of tubes, outside (inches),	2	2.25
19	Length of tubes (feet),	15	15
20	Water heating surface, each boiler (square feet),	2,107	1,645
21	Super heating surface, each boiler (square feet),	832	650
22	Total heating surface, each boiler (square feet),	2,939	2,295
23	Inside area of tubes, each boiler (square feet),	6.82	5.89
24	Grate diameter (feet),	7	6.5
25	Grate area, each boiler (square feet),	38.48	33.18
26	Ratio of water heating to grate surface,	56.57 to 1	49.58 to 1
27	Ratio of total heating to grate surface,	76.38 to 1	69.17 to 1
28	Ratio of grate to inside area of tubes,	5.64 to 1	5.63 to 1
29	Economizer heating surface outside of tubes (square feet),	1,728	1,728
30	Height of stack (feet),	125	125
31	Inside diameter of stack (feet),	4.5	4.5

Trial Data and Results.

		LOW-SERVICE ENGINES.			Northern High-service Engine Number 9.
		Number 5.	Number 6.	Number 7.	
32	Date of trial,	-*	-*	-*	-†
33	Duration of trial,	24 hrs.	24 hrs.	24 hrs.	24 hrs.

* 10 A.M. April 30 to 10 A.M. May 1, 1901. † 10 A.M. June 4 to 10 A.M. June 5, 1901.

Average Pressures.

34	Steam at boilers (pounds),	-	153.71	-	151.03
35	Steam at throttle (mercurial gage) (pounds),	-	150.88	-	150.39
36	1st receiver (pounds),	25.01	24.48	24.79	23.41
37	2d receiver (pounds),	—5.95	—4.75	—5.25	—3.58
38	Vacuum (pounds per square inch),	13.49	13.42	13.67	13.20
39	Barometer (pounds per square inch),	14.65	14.65	14.65	14.58
40	H. P. jacket (pounds),	-	150.88	-	150.39
41	I. P. jacket (pounds),	-	40.00	-	40.21
42	L. P. jacket (pounds),	-	3.10	-	2.6
43	Draft in flue at economizer outlet (inches of water).	-	-	-	0.109
44	Draft in flue at end of boiler, economizer inlet (inches of water).	-	0.142	-	0.2425

Average Temperatures, Degrees Fahrenheit.

		LOW-SERVICE ENGINES.			Northern High-service Engine Number 9.
		Number 5.	Number 6.	Number 7.	
45	**Steam at boiler due to pressure,**	-	367.5	-	366.18
46	**Steam at throttle due to pressure,**	-	366.14	-	365.87
47	**Steam entering H. P. cylinder,**	363.6	362.4	365.8	364.57
48	**Steam entering I. P. cylinder,**	268.5	266.1	268.2	266.31
49	**Steam entering L. P. cylinder,**	197.1	195.5	193.6	201.72
50	**Water from L. P. jacket,**	177.2	187.1	186.5	199.5
51	**Water discharged from air pump,**	97.0	100.6	91.5	105.4
52	**Water entering economizer,**	-	85.0	-	92.82
53	**Water leaving economizer (fed to boiler),**	-	121.2	-	157.90
54	**Water condenser circulating inlet (water pumped).**	-	48.2	-	58.86
55	**Flue gases leaving boiler,**	-	412.0	-	437.0
56	**Flue gases leaving economizer,**	-	227.3	-	230.6

Head Pumped Against.

57	Average elevation of water in force main above Boston city base (feet).	178.063	178.060	177.06	286.845
58	Average elevation of water in wet well above Boston city base (feet).	132.97	133.088	133.06	161.57
59	Average net head pumped against (feet),	45.093	44.972	44.00	125.275

Revolutions.

60	Total revolutions during 24 hours,	43,292	43,287	43,290	35,789
61	Average revolutions per minute,	30.0639	30.0604	30.0625	24.853

Useful Work performed by Engine.

62	Total water pumped (no allowance for slip) (U. S. gallons).	36,284,300	36,268,900	36,280,000	20,396,800

Water fed to Boiler.

63	Total water fed to boilers (pounds),	-	264,568	-	125,211

Steam out of Boilers not used by Engine.

		LOW-SERVICE ENGINES.			Northern High-service Engine Number 9.
		Number 5.	Number 6.	Number 7.	
64	Water from separator (pounds),	-	829	-	217
65	Steam blown through calorimeter (weighed in tank) (pounds).	-	352.4	-	647
66	Leakage from whole plant, exclusive of engines (pounds).	-	4,115.7	-	769
67	Discharge from oil-pressure pipe (pounds),	-	1,385.4	-	-
68	Total steam from boilers not used by engines (pounds).	-	6,682.5	-	1,633
69	Steam chargeable to engines (pounds),	-	257,885.5	-	123,578

Steam received from Engine.

70	From condenser (pounds),	75,280	76,353	72,968	106,345
71	From leak on engine caught and weighed (pounds).	-	58	-	-
72	From L. P. jacket (pounds),	10,806.5	11,491	10,929	16,220.5
73	From second receiver (pounds),	-	-	-	603.5
74	Charged to leaks on engine,	-	-	-	409
75	Total steam used by engines,	86,086.5	87,902	83,897	123,578
76	Average entrainment in steam entering engine at Sp. Pd. (0.7 of 1 p. c.).	-	-	-	865
77	Total dry steam used by engines,	-	257,885.5	-	122,713
78	Percentage of total steam used in jackets,	12.55	13.07	13.03	13.125

British Thermal Units.

79	Total heat used by engine, B. T. U.,	96,288,690	97,892,510	94,104,780	136,056,540
80	Heat contained in one pound of wet coal, B. T. U.	14,023	14,023	14,023	14,110

Horse-power Figures.

81	Average percentage of friction of engine (average of 24 sets of cards).	11.16	11.58	12.57	3.47
82	Average delivered horse-power (useful work),	287.27	286.38	280.27	448.35
83	Average indicated horse-power, H. P. cylinder,	114.11	112.58	111.11	151.93
84	Average indicated horse-power, I. P. cylinder,	104.09	104.10	103.80	138.22
85	Average indicated horse-power, L. P. cylinder,	105.16	107.20	105.66	174.32
86	Total indicated horse-power,	323.36	323.88	320.57	464.47
87	Average moist steam per I. H. P. per hour (pounds).	-	11.10	-	11.09
88	Average dry steam per I. H. P. per hour (pounds).	11.08	11.31	10.92	11.01
89	Average B. T. U. per I. H. P. per minute,	206.79	209.99	203.86	203.42

Coal and Rate of Combustion and Evaporation.

		Low-service Engines.			Northern High-service Engine Number 9.
		Number 5.	Number 6.	Number 7.	
90	Total moist coal burned in 24 hours (pounds),	-	26,542	-	12,432
91	Percentage of moisture in coal, . . .	-	2.2	-	3.7
92	Total dry coal burned during test (pounds),	-	25,958	-	11,972
93	Total ashes during test (pounds), . . .	-	1,648	-	783
94	Total combustible during test (pounds), .	-	24,310	-	11,189
95	Moist coal burned per square foot of grate surface per hour (pounds).	-	9.58	-	7.806
96	Moist coal burned per square foot of water heating surface per hour (pounds).	-	0.175	-	0.1574
97	Evaporation per pound of moist coal, actual conditions, including economizer (pounds).	-	9.968	-	10.072
98	Evaporation per pound of dry coal, actual conditions, including economizer (pounds).	-	10.192	-	10.459
99	Evaporation per pound of dry coal, from and at 212° F., including economizer (pounds).	-	12.042	-	12.270
100	Evaporation per pound of dry coal, from and at 212° F., excluding economizer (pounds).	-	11.677	-	11.593
101	Evaporation per square foot of water heating surface per hour (pounds).	-	1.744	-	1.586
102	Moist coal per I. H. P. per hour (pounds), .	-	1.143	-	1.115
103	Dry coal per I. H. P. per hour (pounds), .	-	1.118	-	1.074
104	Kind of coal, ...	-*	-*	-*	-†

* Loyal Hanna Sonman Shaft. † Georges Creek Cumberland.

Duties.

105	Duty per 1,000 pounds steam, contract basis (foot-pounds).	153,574,000	154,815,000	153,750,000	172,405,000
106	Duty per 1,000,000 B. T. U. (foot-pounds), .	141,787,000	139,089,000	143,771,000	156,592,000
107	Duty per 100 pounds moist coal (foot-pounds),	-*	-*	-*	171,376,000
108	Duty per 100 pounds dry coal (foot-pounds),	-†	-†	-†	177,961,000
109	Duty per 1,000 pounds dry steam, . . .	-‡	-‡	-‡	173,620,000

* Average 3 engines, 152,883,000. † Average 3 engines, 156,822,000. ‡ Average 3 engines, 157,349,000.

Efficiencies.

110	Efficiency of mechanism (per cent.), . .	88.84	88.42	87.43	96.53
111	Efficiency of boilers and economizer, actual (per cent.).	-	82.9	-	84.64
112	Efficiency of boilers alone, actual if economizer had not been used (per cent.).	-	80.4	-	79.97
113	Thermal efficiency of engine (per cent.), .	20.50	20.22	20.30	20.85

Weir Measurements.

		Low-service Engines.			Northern High-service Engine Number 9.
		Number 5.	Number 6.	Number 7.	
114	Length of weir (feet),	-	-	-	5.991
115	Average depth of water on weir (feet),	-	-	-	1.337
116	Calculated discharge over weir (gallons),	-	-	-	20,142,500
117	Leakage from force main during test (gallons),	-	-	-	1,120
118	Water drawn from force main during test (gallons).	-	-	-	4,080
119	Plunger displacement of pumps (gallons),	-	-	-	20,396,800
120	Slip (per cent.),	-	-	-	1.22

APPENDIX No. 5.

SUMMARY OF STATISTICS FOR THE YEAR 1901.

The Metropolitan Water Works supply the Metropolitan Water District, which includes the following cities and towns: —

CITIES AND TOWNS.	Population, Census of 1900.	Estimated Population, May 1, 1901.
Boston,	560,892	573,200
Somerville,	61,643	63,600
Chelsea,	34,072	34,700
Malden,	33,664	34,700
Newton,*	33,587	34,900
Everett,	24,336	25,500
Quincy,	23,899	24,900
Medford,	18,244	19,100
Hyde Park,*	13,244	13,600
Melrose,	12,962	13,300
Revere,	10,395	11,200
Watertown,	9,706	10,100
Arlington,	8,603	9,000
Stoneham,	6,197	6,300
Winthrop,	6,058	6,500
Belmont,	3,929	4,200
Nahant,	1,152	1,200
Total population of Metropolitan Water District,	862,583	886,000
Swampscott,†	4,548	4,700

* No water supplied to these places during the year from Metropolitan Water Works.

† Swampscott is not in the Metropolitan Water District, but has been supplied with water from the Metropolitan Water Works.

Sources of Supply.

SOURCE.	Area of Watershed (Square Miles).	Remarks.
Lake Cochituate,	18.87	Works built by city of Boston in 1848.
Sudbury River,	75.20	Works built by city of Boston in 1872-78.
Nashua River,	118.23	Works begun in 1895; not finished.

Mode of Supply.

Pumping to reservoirs.

Pumping.

Chestnut Hill High-service Station: —

Builders of pumping machinery, Holly Manufacturing Company, Quintard Iron Works and E. P. Allis Company.

Description of coal used: Bituminous; Georges Creek Cumberland and Loyal Hanna Sonman Shaft; anthracite coal screenings. Price per gross ton in bins: $4.29 to $4.78; screenings, $2.24 to $2.80. Average price per gross ton, $4.29. Per cent. ashes, 9.6.

Chestnut Hill Low-service Station: —

Builders of pumping machinery, Holly Manufacturing Company.

Description of coal used: Bituminous; Loyal Hanna Sonman Shaft. Price per gross ton in bins, $4.29 to $4.78. Average price per gross ton, $4.44. Per cent. ashes, 8.9.

Spot Pond Station: —

Builders of pumping machinery, Geo. F. Blake Manufacturing Company and Holly Manufacturing Company.

Description of coal used: Bituminous; Georges Creek Cumberland; anthracite coal screenings. Price per gross ton in bins, $4.37 to $4.48; screenings, $2.24. Average price per gross ton, $4.41. Per cent. ashes, 9.7.

	CHESTNUT HILL HIGH-SERVICE STATION.				
	Engines Nos. 1 and 2.	Engines Nos. 1 and 2 (Low-service).	Engine No. 3.	Engine No. 3 (Low-service).	Engine No. 4.
Coal consumed for year (pounds), . .	499,756	310,069	953,488	482,009	6,346,061
Cost of pumping, figured on pumping station expenses.	$2,152.56	$1,946.59	$4,436.79	$2,427.15	$27,193.97
Total pumpage for year (million gallons),	202.47	204.51	1,016.57	645.58	8,584.11
Average dynamic head, ...	124.33	48.13	125.25	67.77	126.31
Gallons pumped per pound of coal, . .	608.13	1,077.18	1,102.38	1,478.94	1,352.67
Duty, on basis of plunger displacement, .	65,760,000	45,090,000	118,600,000	86,090,000	144,450,000
Cost per million gallons raised to reservoir,	$10.632	$9.518	$4.364	$3.760	$3.168
Cost per million gallons raised one foot, .	.086	.198	.035	.055	.025

	CHESTNUT HILL LOW-SERVICE STATION.	SPOT POND STATION.	
	Engines Nos. 5, 6 and 7.	Engine No. 8.	Engine No. 9.
Coal consumed for year (pounds), ...	8,528,670	344,975	2,076,021
Cost of pumping, figured on pumping station expenses, .	$39,587.97	$1,917.93	$11,463.13
Total pumpage for year (million gallons), ...	26,354.40	351.89	2,414.53
Average dynamic head, ...	48.37	114.54	119.50
Gallons pumped per pound of coal, ...	3,090.09	1,020.04	1,163.06
Duty on basis of plunger displacement, ...	126,420,000	99,320,000	117,700,000
Cost per million gallons raised to reservoir, ...	$1.502	$5.450	$4.748
Cost per million gallons raised one foot, ...	.031	.048	.040

Consumption.

Estimated total population of the sixteen cities and towns supplied wholly or partially during the year 1901, . . .	844,800
Total consumption, gallons, ...	37,044,840,000
Furnished from Metropolitan Water Works sources, gallons, .	36,830,240,000
Furnished from local sources, gallons, ...	214,600,000
Average daily consumption, gallons, ...	101,492,000
Gallons per day each inhabitant, ...	120.1

Distribution.

	Owned and operated by Metropolitan Water and Sewerage Board.	Total in District supplied by Metropolitan Water Works.
Kind of pipe used, ...	-*	-†
Sizes, ...	60 to 6 inch.	60 to 4 inch.
Extension less length abandoned, miles, ...	2.18	36.17
Length in use, miles, ...	72.00	1,396.5
Stop gates added, ...	12	-
Stop gates now in use, ...	280	-
Service pipes added, ...	-	4,044
Service pipes now in use, ...	-	138,540
Meters added, ...	-	645
Meters now in use, ...	-	11,030
Fire hydrants added, ...	-	366
Fire hydrants now in use, ...	-	12,279

* Cast-iron and cement-lined wrought iron. † Cast-iron, cement-lined wrought iron and kalamine.

APPENDIX No. 6.

COMMONWEALTH OF MASSACHUSETTS.

SUFFOLK, SS. SUPREME JUDICIAL COURT IN EQUITY.

JAMES A. BAILEY AND OTHERS, METROPOLITAN SEWERAGE COMMISSIONERS, PETITIONERS, *in re* THE NORTH METROPOLITAN SYSTEM OF SEWERAGE.

REPORT AND AWARD OF COMMISSIONERS.

The North Metropolitan System of Sewerage originally included a portion of the city of Boston, the cities of Cambridge, Somerville, Malden, Chelsea, Woburn, Melrose, Medford and Everett, and the towns of Stoneham, Winchester, Arlington, Belmont and Winthrop.

Under the provisions of chapter 414, Acts of the year 1896, and of chapter 172, Acts of the year 1900, the town of Wakefield was included in this system. Under the provisions of chapter 520, Acts of the year 1897, " the territory comprising the villages of Centre and East Lexington in the town of Lexington " was added to the district.

In May, 1891, Ebenezer R. Hoar, William C. Endicott and John E. Sanford were appointed, under decree of this court, commissioners to determine the proportions which the several cities and towns included in the North Metropolitan and Charles River systems should, for the first term of five years, namely, from 1891 to 1895, inclusive, annually pay money into the treasury of the Commonwealth to meet the interest and sinking fund requirements for each year, and to meet the cost of maintenance and operation for each year.

In October, 1895, Edmund H. Bennett, John E. Sanford and Everett C. Bumpus were appointed, under a decree of this court, to make a similar apportionment for those systems for the second term of five years, namely, from 1896 to 1900, inclusive.

Under the provisions of chapter 424, Acts of the year 1899, the Charles River System was made a part of the South Metropolitan System of Sewerage.

Under decree of this court, dated May 16, 1901, the undersigned were appointed commissioners to make the apportionment for the North Metropolitan Sewerage System for a third term of five years, namely, from 1901 to 1905, inclusive.

Acting under the authority thus granted and in the performance of the duty thus imposed, several hearings have been given, after due notice to all parties in interest in the matter submitted to our decision. These hearings were held at the rooms of the Railroad Commission, 20 Beacon Street, Boston, upon the twentieth day of June, the first, ninth and thirtieth days of July and the fifth day of August in this year.

From the statement of the Treasurer and Receiver-General of the Commonwealth, it appears that, to meet the necessary payments into the treasury of the Commonwealth on account of the North Metropolitan System of Sewerage for the current year, there is required for sinking fund $46,385.79 ; for interest, $169,325 ; and for cost of maintenance and operation, in accordance with legislative appropriation, $76,500. We understand that this appropriation for cost of maintenance and operation was less than it otherwise would have been for the reason that there were available unexpended balances of former appropriations amounting to about $20,000.

In the language of the statute, the apportionment of these expenses is to be made in such manner as the commissioners "shall deem just and equitable." We have been urged by the representatives of several municipalities to adopt a different method of distribution than that followed by the commissioners who have previously made the apportionment; but the weight of opinion expressed at the hearings was very clearly in favor of continuing the methods hitherto adopted, and in our judgment, particularly in view of precedent, the weight of argument demands such course. Accordingly, we have made an apportionment of the payments necessary to meet the interest and sinking fund requirements upon the basis of property valuation, as established by chapter 198, Acts of the year 1901; and the apportionment of the payments required to meet the annual cost of maintenance and operation upon the basis of population, as determined by the United States census of 1900, using the proportionate part of such valuation and population in the case of any city or town a part of which only is included in the district.

We are satisfied that the plan adopted accomplishes substantial justice in the distribution of the burden in accordance with benefits received.

It was contended on the part of several municipalities that local conditions, particularly the character of the watersheds in these cities and towns, were such as to prevent them from receiving the full benefit of the system, and that they were entitled to have consideration given to this fact. The evidence presented, however, failed to convince us that in any instance it was physically impracticable to make use of the system, and, on the whole, tended to show that these cities and towns received such benefit as to warrant an assessment upon them under the rule above stated.

Interest and Sinking Fund.

The commissioners appointed by this court in 1895 considered the amount of contribution which the town of Wakefield ought to make toward the cost of construction previous to the addition to the district of that portion of the town which was annexed to it by chapter 414, Acts of the year 1896. The Board of Metropolitan Sewerage Commissioners determined the amount of contribution which the town of Lexington ought to make toward the cost of construction previous to the addition to the district of a portion of the town by chapter 520, Acts of the year 1897. We have given consideration in this proceeding to the fact that the town of Wakefield in respect to that portion of the town made a part of this district by chapter 172 of the Acts of the year 1900 has not fully contributed to the previous cost of construction.

We therefore determine as just and equitable that the several cities and towns in the North Metropolitan System of Sewerage shall annually pay money into the treasury of the Commonwealth for a term of five years, viz., 1901 to 1905, both inclusive, to meet interest and sinking fund requirements for each of said years, as estimated by the State Treasurer, of that portion of the Metropolitan Sewerage Loan authorized and issued for the construction of said system, and any deficiency in the amount previously paid in, as found by the said Treasurer, in the proportions set down in the following table: —

Table showing Proportions in Percentages in which the Several Cities and Towns in the North Metropolitan System shall pay Money into the Treasury of the Commonwealth, to meet Interest and Sinking Fund Requirements under the Provisions of the Statutes relating thereto.

CITY OR TOWN.	Proportion.	CITY OR TOWN.	Proportion.
Arlington,	2.39	Melrose,	3.41
Belmont,	1.50	Somerville,	13.87
Boston,*	16.89	Stoneham,	1.35
Cambridge,	25.75	Wakefield,	2.35
Chelsea,	6.20	Winchester,	2.41
Everett,	4.81	Winthrop,	1.81
Lexington,†	.90	Woburn,	2.80
Malden,	8.16		
Medford,	5.40	Total,	100.00

* East Boston and Charlestown districts.

† Villages of Centre and East Lexington.

Maintenance and Operation.

The towns of Lexington and Wakefield have not as yet connected any local sewers with the Metropolitan System. It was contended by counsel that, until such connection has been made, these towns are exempt from assessment for any part of the cost of maintenance and operation under the provisions of section 10, chapter 520, Acts of the year 1897, relating to Lexington, and section 7, chapter 172, Acts of the year 1900, relating to Wakefield. We are of the opinion, however, that the exemptions named in those statutes are binding only upon the Board of Metropolitan Sewerage Commissioners in making their annual apportionment, and do not limit our

authority or control us in our duty in dealing with these towns. It was further contended that if, as a matter of law, these exemptions did not apply in this proceeding, through them the Legislature had declared a rule of equity which ought to govern us in making the apportionment. We cannot fully accept this proposition, as it seems to us that the territorial character of the district and benefits received and to be received justify the assessment upon each town of some portion of the expense of maintenance and operation, as well as of the construction of the system. The system is complete and ready for connection with local sewers in these towns. In Wakefield the work of effecting such connection is well under way, and will undoubtedly be finished within a comparatively short time. There appears to be no reason why the town of Lexington cannot readily within the next five years connect local sewers with the system. We have given what we believe to be due consideration to these facts and to all the conditions affecting these towns in making the following table of proportions.

We therefore determine as just and equitable that the several cities and towns in the North Metropolitan System of Sewerage shall annually pay money into the treasury of the Commonwealth for the term of five years, viz., 1901 to 1905, both inclusive, to meet the cost of maintenance and operation of said system for each of said years as estimated by the Metropolitan Water and Sewerage Board (the successor of the Board of Metropolitan Sewerage Commissioners) and certified to said Treasurer, and any deficiency in the amount previously paid in as found by said treasurer in the proportions set down in the following table: —

Table showing Proportions in Percentages in which the Several Cities and Towns in the North Metropolitan System shall pay Money into the Treasury of the Commonwealth, to meet the Cost of Maintenance and Operation, under the Provisions of the Statutes relating thereto.

CITY OR TOWN.	Proportions.	CITY OR TOWN.	Proportions.
Arlington,	2.06	Melrose,	3.10
Belmont,	.94	Somerville,	14.74
Boston,*	20.66	Stoneham,	1.48
Cambridge,	21.96	Wakefield,	1.78
Chelsea,	8.14	Winchester,	1.73
Everett,	5.82	Winthrop,	1.45
Lexington,†	.32	Woburn,	3.41
Malden,	8.05		
Medford,	4.36	Total,	100.00

East Boston and Charlestown districts.

† Villages of Centre and East Lexington.

(Signed) JAMES F. JACKSON,
LARKIN T. TRULL,
ARTHUR P. RUGG,
Commissioners.

AUGUST 5, 1901.

APPENDIX NO. 7.

LEGISLATION OF THE YEAR 1901 AFFECTING THE METROPOLITAN WATER AND SEWERAGE BOARD.

ACTS.

[CHAPTER 30.]

AN ACT MAKING AN APPROPRIATION FOR OPERATING THE SOUTH METROPOLITAN SYSTEM OF SEWAGE DISPOSAL.

Be it enacted, etc., as follows:

South metropolitan system of sewage disposal.

SECTION 1. A sum not exceeding seventy thousand five hundred and sixty dollars is hereby appropriated, to be paid out of the treasury of the Commonwealth from the ordinary revenue, for the cost of maintenance and operation of the south metropolitan system of sewage disposal, comprising a part of the city of Boston, the cities of Quincy, Newton and Waltham, and the towns of Brookline, Watertown, Dedham, Hyde Park and Milton.

SECTION 2. This act shall take effect upon its passage. [*Approved February 6, 1901.*

[CHAPTER 40.]

AN ACT MAKING AN APPROPRIATION FOR OPERATING THE NORTH METROPOLITAN SYSTEM OF SEWERAGE.

Be it enacted, etc., as follows:

North metropolitan system of sewage disposal.

SECTION 1. A sum not exceeding seventy-six thousand five hundred dollars is hereby appropriated, to be paid out of the treasury of the Commonwealth from the ordinary revenue, for the maintenance and operation of the system of sewage disposal for the cities of Boston, Cambridge, Somerville, Malden, Chelsea, Woburn, Medford, Melrose and Everett, and the towns of Stoneham, Winchester, Arlington and Belmont, known as the North Metropolitan System, during the year ending on the thirty-first day of December, nineteen hundred and one.

SECTION 2. This act shall take effect upon its passage. [*Approved February 12, 1901.*

[CHAPTER 104.]

AN ACT TO PROVIDE FOR EXAMINATION BY THE STATE BOARD OF HEALTH OF THE OUTLETS OF SEWERS, AND AS TO THE EFFECT OF SEWAGE DISPOSAL.

Be it enacted, etc., as follows:

State board of health to examine outlets of sewers, etc.

SECTION 1. The state board of health shall annually examine all main outlets of sewers and drainage of the cities and towns of the Commonwealth, and the effect of sewage disposal, and annually report thereon to the general court, with such recommendations for the protection of the interests of persons and property as said board shall deem expedient, and for the prevention of offensive odors and objectionable conditions.

SECTION 2. This act shall take effect upon its passage. [*Approved March 5, 1901.*

[CHAPTER 168.]

AN ACT TO CONSOLIDATE THE METROPOLITAN WATER BOARD AND THE BOARD OF METROPOLITAN SEWERAGE COMMISSIONERS.

Be it enacted, etc., as follows:

Metropolitan Water and Sewerage Board created.

SECTION 1. A board is hereby created which shall be known as the Metropolitan Water and Sewerage Board, and shall consist of three members, who shall be appointed by the governor with the advice and consent of the council.

Term of office of members, etc.

SECTION 2. The term of office of the members of said board shall be three years, beginning from the date of their appointment, but of the members first appointed one shall be appointed for the term of five years, one for the term of four years and one for the term of three years from said date of appointment.

Chairman, etc.

The governor shall designate one of the members of said board as chairman, and shall also designate the term for which each member is appointed.

Compensation.

SECTION 3. The chairman of said board shall receive a salary of five thousand dollars a year, and each of the other members shall receive a salary of forty-five hundred dollars a year.

Removals, vacancies.

Section 4. The governor shall have power to remove any member of said board, with the advice and consent of the council, and to fill all vacancies therein, by appointing for the remainder of any unexpired term in the same manner in which appointments are authorized for a full term.

The metropolitan water board and board of metropolitan sewerage commissioners abolished, etc.

Section 5. The metropolitan water board and the board of metropolitan sewerage commissioners are hereby abolished. All the powers, rights, duties and liabilities of said metropolitan water board and of said board of metropolitan sewerage commissioners, and of each of them, are hereby transferred to the Metropolitan Water and Sewerage Board created by this act. No existing contracts, liabilities or suits shall be affected hereby, but the board hereby created shall in all respects and for all purposes whatsoever be the lawful successor of said metropolitan water board and of said board of metropolitan sewerage commissioners.

Existing contracts, etc., not affected.

Section 6. This act shall take effect upon its passage. [*Approved March 20, 1901.*

[Chapter 204.]

An Act to provide additional sewerage facilities for the city of Newton and the town of Brookline.

Be it enacted, etc., as follows:

Metropolitan sewer to be extended.

Section 1. The metropolitan water and sewerage board shall extend the metropolitan sewer from a branch in St. Joseph's cemetery in West Roxbury to and across the boundary line between Newton and Brookline, in the manner best adapted to serve the sewerage needs of those municipalities.

Newton and Brookline, etc., may make connections with sewers.

Section 2. The city of Newton and the town of Brookline, and any persons and corporations, may, subject to the control and under the direction of the said board, make connections with any sewers constructed by the board under the authority of this act.

The metropolitan water and sewerage board to exercise certain authority, etc.

Section 3. In making said extension and in receiving sewage from said districts, and in any action relating thereto, and for the purpose of constructing and maintaining said additional main lines of sewer, the said board, acting on behalf of the Commonwealth, shall have and exercise all the authority conferred by chapter four hundred and thirty-nine of the acts of the year eighteen hundred and eighty-nine, by chapter four hundred and six of the acts of the year eighteen hundred and ninety-five, and by acts in amendment thereof and in addition thereto regarding the original system or anything relating thereto, and by chapter one hundred and sixty-eight of the acts of the year nineteen hundred and one; and all the provisions of said chapters are hereby made applicable to this additional construction, except as herein otherwise provided.

Metropolitan Sewerage Loan.

SECTION 4. To meet the expenses incurred under the provisions of this act the treasurer and receiver general shall, with the approval of the governor and council, issue scrip or certificates of debt, in the name and behalf of the Commonwealth and under its seal, to an amount not exceeding forty thousand dollars, for a term not exceeding forty years. Such scrip or certificates of debt shall be issued as registered bonds or with interest coupons attached, and shall bear interest at a rate not exceeding four per cent per annum, payable semi-annually on the first days of March and September in each year. The said interest and scrip or certificates shall be payable and when due shall be paid in gold coin or its equivalent. Said scrip or certificates of debt shall be designated on their face, Metropolitan Sewerage Loan, shall be countersigned by the governor, and shall be deemed a pledge of the faith and credit of the Commonwealth, redeemable at the time specified therein, in gold coin or its equivalent, and shall be sold or disposed of at public auction or in such other mode and at such times and prices and in such amounts and at such rate of interest, not exceeding four per cent per annum, as the treasurer and receiver general with the approval of the governor and council shall deem for the best interests of the Commonwealth. Any scrip or certificates of debt issued under the provisions of this act shall be considered as an addition to and shall become a part of the loan authorized by chapter four hundred and six of the acts of the year eighteen hundred and ninety-five and acts in amendment thereof and in addition thereto.

Payment of loan, etc.

SECTION 5. The interest and sinking fund requirements of the moneys expended in constructing that part of the sewerage system provided for in this act, and the cost of maintenance and operation thereof, shall be deemed and paid as a part of the interest, sinking fund requirements and costs specified in said chapter four hundred and six and acts in amendment thereof and in addition thereto; and the sinking fund established under the provisions of said chapter shall be a sinking fund for the extinguishment of the debt authorized by this act, said funds to be increased in the following manner: — The treasurer and receiver general shall from year to year, beginning with the year nineteen hundred and one, apportion to said sinking fund an amount sufficient with its accumulations to extinguish the debt at maturity; and in making the assessment for the increase of said sinking fund upon the several cities and towns liable thereto such proportions of the whole amount shall be assessed in each year as will harmonize with the proportions to be assessed on account of the sinking fund for loans now outstanding for the Neponset river valley metropolitan sewer system. Any premium realized from the sale of said scrip or certificates of debt shall be applied to the payment of the interest on said loan as it accrues.

When to take effect.

SECTION 6. This act shall take effect when the town of Brookline appropriates money to construct a sewer or sewers in said town to connect with the extension of the metropolitan sewer provided for by this act. [*Approved March 26, 1901.*

[CHAPTER 313.]

AN ACT TO AUTHORIZE THE TEMPORARY TAKING OF WATER FOR EMERGENCY PURPOSES BY CITIES AND TOWNS.

Be it enacted, etc., as follows:

Cities and certain towns may in cases of emergency take water from certain brooks, etc.

SECTION 1. Cities by their city councils, and towns having a system of water supply by their water commissioners or selectmen, may in cases of emergency and for a period not exceeding six months in any one year, take water from any brook, stream, river, lake, pond or reservoir, not already appropriated to uses of a municipal water supply, in such quantities as may be necessary to relieve the emergency; but water commissioners or selectmen of towns shall not make any such taking unless previously authorized so to do at some meeting of the inhabitants of the town regularly called therefor. They may also take such rights to use any land and for such time as may be necessary to use such water. Such vote of a city council or of a town meeting shall be conclusive as to the existence of the emergency. No such taking shall be made until the state board of health shall have first approved the water as a proper source of water supply.

Water to be approved by state board of health.

Description of taking to be recorded, etc.

SECTION 2. The city councils of cities and the water commissioners or selectmen of towns shall cause to be recorded in the registry of deeds for the county or district in which such water and land are situated, within thirty days after the taking, a description sufficiently accurate for identification, with a statement of the purpose and the time for which the same are taken, which statement shall be signed by the mayor of the city or by the chairman of the water commissioners or selectmen of the town making the taking, and upon such recording the right to use for the time stated in such taking shall vest in such city or town.

Damages.

SECTION 3. The city councils of cities and the water commissioners or selectmen of towns shall within sixty days after the termination of the exercise of any right taken under the provisions of this act estimate and determine, as near as may be, the actual damages sustained by any person by the taking of any water and of the right to use any land under this act; but any one aggrieved by such determination may have such damages assessed by a jury of the superior court, in the same manner as is provided by law with respect to damages sustained by the laying out of ways. If upon trial damages are increased beyond the amount determined as aforesaid, the aggrieved person shall recover costs, otherwise such person shall pay costs, and costs shall be taxed as in civil cases; but no suit or petition for such damages shall be brought after the expiration of two years from the date of the recording of the description and statement as aforesaid.

Certain duties, etc., to be exercised by the metropolitan water and sewerage board.

SECTION 4. The powers conferred upon and the duties to be performed by the city councils and mayors of cities under this act shall within those cities and towns using the metropolitan water supply be exercised by the metropolitan water and sewerage board. [*Approved April 23, 1901.*

[CHAPTER 429.]

AN ACT MAKING AN APPROPRIATION FOR MAINTAINING AND OPERATING THE QUINCY PUMPING STATION AND FORCE MAINS IN THE SOUTH METROPOLITAN SEWERAGE SYSTEM.

Be it enacted, etc., as follows:

Maintenance, etc., of Quincy pumping station, etc.

SECTION 1. A sum not exceeding fifty-five hundred dollars is hereby appropriated, to be paid out of the treasury of the Commonwealth from the ordinary revenue, for the maintenance and operation during the year ending on the thirty-first day of December, nineteen hundred and one, of the Quincy pumping station and force mains taken by the metropolitan water and sewerage board.

SECTION 2. This act shall take effect upon its passage. [*Approved May 23, 1901.*

[CHAPTER 442.]

AN ACT RELATIVE TO BONDS REQUIRED TO BE GIVEN UNDER CERTAIN CONTRACTS MADE BY THE METROPOLITAN WATER AND SEWERAGE BOARD.

Be it enacted, etc., as follows:

1897, 339, amended.

Certain rights, etc., of cities and towns not affected.

Chapter three hundred and thirty-nine of the acts of the year eighteen hundred and ninety-seven is hereby amended by inserting at the end thereof the following: — Nothing herein contained shall be construed to deprive any city or town of any rights or remedies under laws existing at the time of the passage of this act. [*Approved May 29, 1901.*

[CHAPTER 453.]

AN ACT TO PROVIDE FOR AN ADDITIONAL METROPOLITAN WATER LOAN.

Be it enacted, etc., as follows:

Metropolitan Water Loan.

SECTION 1. The treasurer and receiver general of the Commonwealth shall from time to time, on the request of the metropolitan water and sewerage board, issue negotiable bonds in the name and behalf of the Commonwealth and under its seal, designated on the face thereof, Metropolitan Water Loan, to an amount not exceeding thirteen million dollars, in addition to the twenty-seven million dollars authorized to be issued under the provisions of section seventeen of chapter four hundred and eighty-eight of the acts of the year eighteen hundred and ninety-five; and the provisions of said chapter and of acts in amendment thereof and in addition thereto shall apply to this additional loan, to the same extent as if the amount authorized by said act had been forty million dollars instead of twenty-seven million dollars.

SECTION 2. This act shall take effect upon its passage. [*Approved June 5, 1901.*

[CHAPTER 489.]

AN ACT TO CHANGE THE AMOUNT TO BE ASSESSED ANNUALLY UPON CITIES AND TOWNS UNDER THE ACT TO PROVIDE FOR A METROPOLITAN WATER SUPPLY.

Be it enacted, etc., as follows:

1895, 488, § 19, amended.

SECTION 1. Section nineteen of chapter four hundred and eighty-eight of the acts of the year eighteen hundred and ninety-

Treasurer to estimate amount required for payment of expenses, etc.

Provisos.

Payment of assessments.

five, being "An act to provide for a Metropolitan Water Supply", is hereby amended by striking out all after the word "treasurer", in the thirty-second line, to and including the word "apportioned", in the forty-fourth line, so as to read as follows: — *Section 19.* Said treasurer shall in each year estimate the amount, in addition to the premiums from sales of said bonds and the proceeds from the operations of said board, exclusive of the proceeds from sales of property, required during the year to pay the interest, sinking fund requirements, expenses of maintenance and operation of said water works, and shall apportion to the city of Boston the proportion of such amount that the valuation of said city for the preceding year bears to the total of all such valuations of all cities and towns in said water district: *provided*, *however*, there shall be included only one sixth of the total valuation of any such city and town which has not reached the safe capacity of its present sources of supply in a dry year, as determined by said water board and certified to said treasurer, and has not made application to said board for water, and the remainder to the other cities and towns in said district, one third in proportion to their respective valuations and the remaining two thirds in proportion to their respective populations, including however only one sixth of the total valuation and one sixth of the total population of any such city and town which has not reached the safe capacity of its sources or of the sources of supply of the water company by which a town is supplied, or has not made application for water as aforesaid; and *provided*, *further*, that any city or town assessed upon its full valuation and population, which furnishes a part of its water supply from its own works or receives a supply from a water company, shall be allowed and credited in its apportionment with a sum equal to twelve dollars for each million gallons of water furnished as aforesaid, as determined by said water board and certified to said treasurer. Said treasurer shall in each year notify each city and town of the amount of its assessment, and the same shall be paid by the city or town into the treasury of the Commonwealth at the time required for the payment and as part of its state tax.

SECTION 2. This act shall take effect upon its passage. [*Approved June 13, 1901.*

[Chapter 498.]

An Act to extend the time for filing petitions for damages, and offers of surrender of real estate, under the act to provide for a metropolitan water supply.

Be it enacted, etc., as follows:

1899, 342, § 1, etc., amended.

Section 1. Section one of chapter three hundred and forty-two of the acts of the year eighteen hundred and ninety-nine, as amended by section one of chapter one hundred and eight of the acts of the year nineteen hundred, is hereby further amended by striking out the word "one", in the seventeenth line, and inserting in place thereof the word: — four, — so as to read as follows: — *Section 1.* Petitions under the provisions of section fourteen of chapter four hundred and eighty-eight of the acts of the year eighteen hundred and ninety-five, or of section one of chapter four hundred and forty-five of the acts of the year eighteen hundred and ninety-seven, and acts in amendment thereof or in addition thereto, for the determination of damages for the taking of real estate may be filed, as provided by law, within two years after the actual taking by right of eminent domain of such real estate or of any interest therein, and petitions for the determination of damages for the taking of water rights where no land is taken in connection with such water rights, and for the determination of all other damage provided for in said acts, and offers of surrender of real estate provided for in said acts, may be filed on or before the first day of July in the year nineteen hundred and four.

Time within which certain petitions for damages, etc., may be filed, extended.

Section 2. This act shall take effect upon its passage. [*Approved June 13, 1901.*

[Chapter 505.]

An Act relative to the payment to certain persons in the town of Clinton of damages sustained under the act to provide for a metropolitan water supply.

Be it enacted, etc., as follows:

1895, 488, § 14, etc, amended.

Section 1. Section fourteen of chapter four hundred and eighty-eight of the acts of the year eighteen hundred and ninety-five, as amended by chapter five hundred and fifty-one of the acts of the year eighteen hundred and ninety-eight, is hereby further amended by inserting after the word "Boylston", in the fifth and eleventh lines, respectively, of section one of said chapter five hundred and fifty-one, the words: — or in that part of the town of Clinton within the limits of the Wachusett reservoir, — so that said section fourteen of chapter four hundred and eighty-eight, after the word "court", in the fiftieth line, shall read as follows: — In case any individual or firm owning on the first day of April in the year eighteen hundred and ninety-five an established business on land in the town of West Boylston, or on land in the town of Boylston, or in that part of the town of Clinton within the limits of the Wachusett reservoir, whether the same shall be taken or not under this act, or the heirs or personal representatives of such individual or firm, shall deem that such business is decreased in value by the carrying out of this act, whether by loss of custom or otherwise, and unable to agree with said board as to the amount of damages to be paid for such injury, such damages shall be determined and paid in the manner hereinbefore provided. The words "real estate", as used in this section, shall include water rights, and in the case of mills all machinery thereon.

Determination of damages to certain business establishments.

Words "real estate" defined.

SECTION 2. This act shall take effect upon its passage. [*Approved June 14, 1901.*

[CHAPTER 509.]

AN ACT TO REQUIRE THE METROPOLITAN WATER AND SEWERAGE BOARD TO IMPROVE THE CONDITION OF THE COCHITUATE WATER BASIN.

Be it enacted, etc., as follows:

Condition of Cochituate water basin to be improved, etc.

SECTION 1. The metropolitan water and sewerage board, within two years from the passage of this act, shall cause that part of the Cochituate reservoir known as Pegan Meadow, located in the town of Natick, and that part of said reservoir in the towns of Wayland and Natick known as Snake Brook meadow, to be cleaned and excavated to a level of three feet above the bottom of the aqueduct from said reservoir, and the banks of the said meadows to be improved so that mud deposits shall not be exposed thereon at low stages of the water; and in the execution of this work the board may decrease the flowed area of the said meadows to such extent as it shall see fit. The cost of said work shall be paid out of the Metropolitan Water

Proviso.

Loan Fund: *provided, however*, that the amount so expended shall not exceed one hundred thousand dollars; and if the board shall find it impossible to excavate said meadows to the depth herein specified and to carry out all the provisions hereof for said sum, then said work shall be prosecuted to such extent as may reasonably be done for the sum of one hundred thousand dollars.

Certain provisions of law to apply.

SECTION 2. The provisions of section twenty-eight of chapter four hundred and eighty-eight of the acts of the year eighteen hundred and ninety-five for the enforcement of the act to provide for a metropolitan water supply shall apply to this act.

SECTION 3. This act shall take effect upon its passage. [*Approved June 14, 1901.*

[CHAPTER 513.]

AN ACT TO AUTHORIZE THE ADVANCEMENT OF MONEYS FOR THE PURPOSES OF THE METROPOLITAN WATER AND SEWERAGE BOARD.

Be it enacted, etc., as follows:

Certain sums of money may be advanced for the purposes of the metropolitan water and sewerage board, etc.

SECTION 1. There may be advanced from the treasury of the Commonwealth to such person as shall be designated by the metropolitan water and sewerage board such sums of money, not exceeding twenty thousand dollars at any one time, as the auditor of accounts may certify to the treasurer of the Commonwealth to be necessary to enable said board to make direct payments upon their pay rolls and other accounts. Said sum may be advanced from any loan or appropriation under the control of the metropolitan water and sewerage board. The person to whom this money is advanced shall within thirty days from the receipt of any sum file with the auditor of accounts a statement in detail of the moneys expended, approved by the metropolitan water and sewerage board, and, where it is practicable to obtain them, receipts or other like vouchers of the persons to whom the payments have been made. The person so designated shall give a bond with sufficient sureties, to be approved by the auditor of accounts, in the sum of twenty thousand dollars.

Repeal.

SECTION 2. All acts and parts of acts inconsistent herewith are hereby repealed.

SECTION 3. This act shall take effect upon its passage. [*Approved June 14, 1901.*

[CHAPTER 516.]

AN ACT TO PROVIDE FOR CERTAIN ANNUAL PAYMENTS TO THE TOWN OF HOPKINTON ON ACCOUNT OF THE CONSTRUCTION OF THE METROPOLITAN WATER SYSTEM.

Be it enacted, etc., as follows:

Treasurer of the Commonwealth to make certain annual payments to the town of Hopkinton.

SECTION 1. The treasurer of the Commonwealth shall pay to the town of Hopkinton as a part of the expenses of the metropolitan water works, the sum of twelve hundred dollars in the month of September in the year nineteen hundred and one, and a like sum in the same month in each succeeding year until ten years after the reservoirs or basins situated in said town cease to be a part of the metropolitan water system: *provided*, that the town shall continue to be a municipality during that time; but shall pay no tax and make no other payment to said town on account of any property held by said water board for the purposes of a water supply.

Proviso.

SECTION 2. This act shall take effect upon its passage. [*Approved June 18, 1901.*

RESOLVES.

[CHAPTER 101.]

RESOLVE TO PROVIDE FOR THE APPOINTMENT OF A COMMITTEE TO DETERMINE WHETHER COMPENSATION SHOULD BE PAID TO THE TOWNS OF CLINTON, STERLING AND HOLDEN BY REASON OF THE CONSTRUCTION OF THE WACHUSETT RESERVOIR BY THE METROPOLITAN WATER AND SEWERAGE BOARD.

Committee to determine as to compensation to Clinton, Sterling and Holden by reason of the construction of the Wachusett reservoir, appointment, etc.

Resolved, That the governor of the Commonwealth is hereby authorized to appoint a committee of three persons to determine whether any, and what amount of, compensation should be paid to the towns of Clinton, Sterling and Holden, as municipalites, and not to the individual citizens thereof, by reason of the construction of the Wachusett reservoir, or of any other acts done under authority of chapter four hundred and eighty-eight of the acts of the year eighteen hundred and ninety-five and the amendments thereof. The said committee shall receive such compensation for their services as the governor and council may fix, and shall report to the general court at its next session, not later than the fifteenth day of January in the year nineteen hundred and two. Any vacancy occurring in the committee may be filled by the governor. [*Approved June 10, 1901.*

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